WATERSHED IMPLEMENTAION PLAN

LITTLE RIVER WATERSHED
SUBSEGMENT 030804

Dissolved Oxygen

Nonpoint Source Unit

Little River Implementation Plan for Dissolved Oxygen

EXECUTIVE SUMMARY

The Little River (030804) watershed has a relatively small drainage area of only 36 sq miles which is composed largely of forested areas and pasture grazing land with intermittent rural residential sites. Little River is a tributary to the West Fork Calcasieu River and meanders for ~17 miles. A Total Daily Maximum Daily Load (TMDL) was established for the bayou in March 2001. The TMDL requires that anthropomorphic Nonpoint Source (NPS) loading should be reduced by 90% in order to meet the State's dissolved oxygen standards of 3.0 mg/l (summer) and 5.0 mg/l (winter).

In addition to natural background, the oxygen demanding materials can be coming from 3 possible sources: silviculture, pasture grazing, and rural residential. There are virtually no traditional agricultural row crops, no urban areas, and there are not any point source facilities in the drainage area. The riparian zones along the bayou are healthy consisting of a mixed hardwoods, cypress, and pine. The stream meanders naturally. The upper reaches of the watershed experience greater slopes and small hills lay across much of the land in the northern section of the watershed. Results from watershed modeling suggest that much of the loading is coming from the elevated northern section of the watershed. The oxygen demanding materials that originate from the upper reaches eventually settle in the lower reaches where the slope levels out.

The TMDL suggest that the majority of the NPS loading is originating from natural sources and that the Little River is naturally dystrophic. The TMDL stream survey was conducted during a drought year (June 2000) under sub-critical conditions. The LDEQ ambient water quality data, which triggered the 303 (d) listing, was also collected during a drought year (1999). The watershed was modeled with the AnnAGNPS soil erosion model and the results indicated a significantly lower pollutant loading compared to other watersheds in southern Louisiana. LDEQ will return to the watershed beginning January 2004 to reevaluate the ambient water quality conditions. The only corrective actions available to reduce anthropomorphic NPS loading in the Little River watershed is to implement Forestry Best Management Practices (BMPs) and to maintain BMPs for the Rural Residential and pasture grazing sites in the area. The BMP implementation should focus efforts in the upper reaches in the northern section of the watershed where greater slopes produce significantly higher runoff events.

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1.0 IMPLEMENTATION PLAN FOR DISSOLVED OXYGEN IN THE LITTLE RIVER WATERSHED

1.1 INTRODUCTION

A TMDL is an acronym for Total Maximum Daily Load, which is the maximum amount of a pollutant that a water body can assimilate and still meet water quality standards for its designated uses. If the water body does not meet the standard for a particular use, a set percentage of the time (depending on the standard), it is placed on the State of Louisiana's 303(d) List of Impaired Waters. The bayou was listed on the 2000, 303(d) Court Ordered Impaired list as not meeting its uses for fish and wildlife propagation. A TMDL was required to be completed on all remaining sources of impairment for Little River (Sub-segment 030804). The Louisiana Department of Environmental Quality (LDEQ) has completed a TMDL for organic enrichment/low DO.

An Implementation Plan describes a plan of action to reduce NPS pollution in the watershed until the streams and rivers will comply with water quality standards. These plans will be the basis for outlining how and where the State's NPS Program focuses its efforts and future resources within the watershed. In Forestry watersheds, such as the Little River, the implementation of Forestry Best Management Practices (BMPs) is the recommended course of action for reducing pollutant runoff. Rural Residential and pasture grazing land runoff also contributes to low DO conditions in the watershed. BMPs for these NPS pollutant sources will be presented in this plan as well. The main course of action for the Little River watershed will be the implementation of Forestry BMPs.

Constituent	LDEQ/EPA Standard	Percent Reduction	Nonpoint Sources of Pollutant
DO and Organic Enrichment	5.0 mg/l Dec – Feb 3.0 mg/l March - Nov	90% 90%	Forestry, Pasture, Rural Residential, Home Sewerage, Hydro-modification, Natural Sources

TABLE 1.1 The water quality standards and the TMDL required reductions are shown above for dissolved oxygen.

1.2 LDEQ DISSOLVED OXYGEN TMDL FINDINGS

The DO TMDL reported that there are no point source dischargers in the watershed and NPS sources accounts for ~100% of the anthropogenic pollution. The TMDL estimates that compliance with the criteria 5 mg/l (winter) and 3mg/l (summer) will require a 90% reduction of man-made NPS pollution. The majority of the data used for the TMDL was obtained during a 3-day intensive stream survey in June of 2000. The area was experiencing severe drought and stream conditions were sub-critical. This means survey conditions were worse than 7Q10 critical conditions, i.e. the 7 hottest and driest days over a normal 10 yr period. Survey results were used to calibrate the TMDL model and sub-critical conditions limit the predictive ability of the model. The ambient water quality (Site No. 58010844) that led to the waterway inclusion on the 303 (d) list was also obtained during drought conditions.

1.3 FEDERAL AUTHORITY

Section 319 of the Clean Water Act (PL 100-4, February 4, 1987) was enacted to specifically address problems attributed to nonpoint sources of pollution. Its objective is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Sec. 101; PL 100-4), which instructs the Governor of each State to prepare and submit a Nonpoint Source Management Program for reduction and control of pollution from nonpoint sources to navigable waters within the State by implementation of a four-year plan (submitted within 18 months of the day of enactment).

1.4 STATE AUTHORITY

In response to the federal law, the State of Louisiana passed Revised Statute 30:2011, signed by the Governor in 1987 as Act 272. Act 272 designated the Louisiana Department of Environmental Quality as the "Lead Agency" for development and implementation of the State's Nonpoint Source Management Plan. The Louisiana Revised Statutes R.S. 30:2011.D (20) include the following provision as the authority for LDEQ to implement the State's NPS Program.

To develop and implement a non-point source management and ground water quality protection program and a conservation and management plan for estuaries, to receive federal funds for this purpose and provide matching state funds when required, and to comply with terms and conditions necessary to receive federal grants. The nonpoint source conservation and management plan, the groundwater protection plan, and the plan for estuaries shall be developed in coordination with, and with the concurrence of the appropriate state agencies, including but not limited to, the Department of Natural Resources, the Department of Wildlife and Fisheries, the Department of Agriculture and Forestry and the State Soil and Water Conservation Committee in those areas pertaining to their respective jurisdictions

LAC 33:IX.1101.D.

The water quality standards described within this chapter are applicable to surface waters of the state and are utilized through the wasteload allocation and permit process to develop effluent limitations for point source discharges to surface waters of the State. These also form the basis for implementing the best management practices for control of nonpoint sources of water pollution.

LAC 33:IX.1109.A.2 Antidegradation Policy

Chapter 11 also states that the administrative authority will not approve any wastewater discharge or certify any activity for federal permit that would impair water quality or use of state waters. Waste discharges must comply with applicable state and federal laws for the attainment of water quality goals. Any new, existing, or expanded point source or nonpoint source discharging into state waters, including land clearing which is the subject of a federal permit application, will be required to provide the necessary level of waste treatment to protect state waters as determined by the administrative authority. Further, the highest statutory and regulatory requirements shall be achieved for all existing point sources and best management practices (BMP's) for nonpoint sources. Additionally, no degradation shall be allowed in high-quality waters that constitute outstanding natural resources, such as waters of ecological significance as designated by the office. Those water bodies presently designated as outstanding resources are listed in LAC 33:IX.1123

1.5 Timeline for Implementation Plan

An Implementation Plan for the watershed restoration actions will be submitted to the EPA in 2004. This document outlines a 5-year management plan to reduce NPS pollutants from reaching the waterways. The LDEQ water quality team intensively samples each watershed in the state once every 5 years to see if the water bodies are meeting water quality standards. This 5-year cycle of water quality sampling began in 1999 in the Little River and will occur again in 2004, 2009, and 2014. In 2004, LDEQ will sample the bayou to see if there has been any improvement since 1999. In 2009, LDEQ will sample again in the watershed to see if the waterway has improved as the result of BMPs recommended in the watershed Implementation Plan. If not, LDEQ will revise the Implementation Plan to include additional corrective actions to bring the waterway into compliance. Additional BMPs will be employed, if necessary, beginning in 2009 and increased until water quality standards are achieved by 2013. The long-term goal for restoring the waterway is 2015. The data from 2003 will be considered baseline from which to measure the rate of the water quality improvement in samples taken in subsequent years. The data collected in 2009 will be used to determine if the implementation of management measures in the Implementation Plan have been effective and corrective actions will be implemented until the water body meets criteria by the year 2015.

1.6 Description of Little River Watershed

The Little River (030804) watershed is a 36.1 sq mile area located in Southwest Louisiana. Average precipitation in the watershed is 56 inches. Little River flows for ~17 mi and is ~6 ft wide at the headwaters and the bayou's width generally increases as it progresses down-stream. Forestry is the dominant landuse in the watershed (52%) and swamps and bottomland hardwoods dominate the lower reaches of the river. Pasture grazing land is in second for landuse composing 42% of the area. The riparian zone along Little River is in excellent condition. It is greater than 100 ft on both sides of the bayou along the entire river. Bottomland hardwoods comprise the largest percent of species of trees along the riparian zone. Hardwoods can be found in large patches throughout the watershed. Some areas contain long needle pines, which will be harvested for timber once they mature. Approximately, 5-10% of the area in the watershed is currently (2003) being harvested for timber. The soils in Little River watershed are primarily silt loams. In general; Guyton and Brimestone soils (k value = 0.49) dominate the terraces and uplands and Ruston and Ouachita soils (k value = 0.37 – 0.43) are the dominant soils on flood plains on the portion of the watershed in Beauregard Parish. In the portion of the watershed in Calcasieu Parish, the predominant soils are Acadia, Arat mucky, Basil, Brimstone, Caddo, Glenmora, Gore, Guyton, Kinder, and Messer silt loams (k values 0.43 – 0.49).

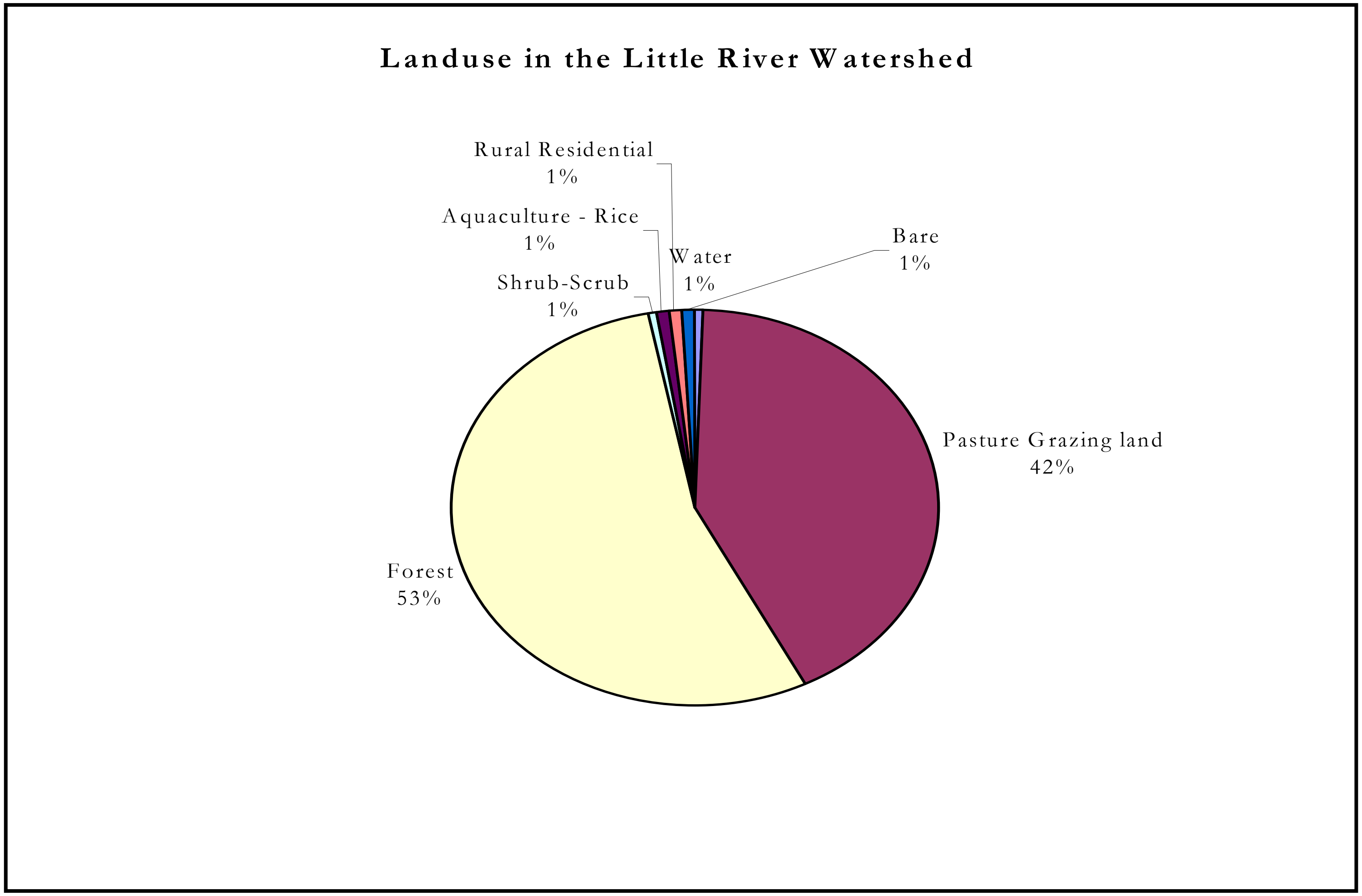
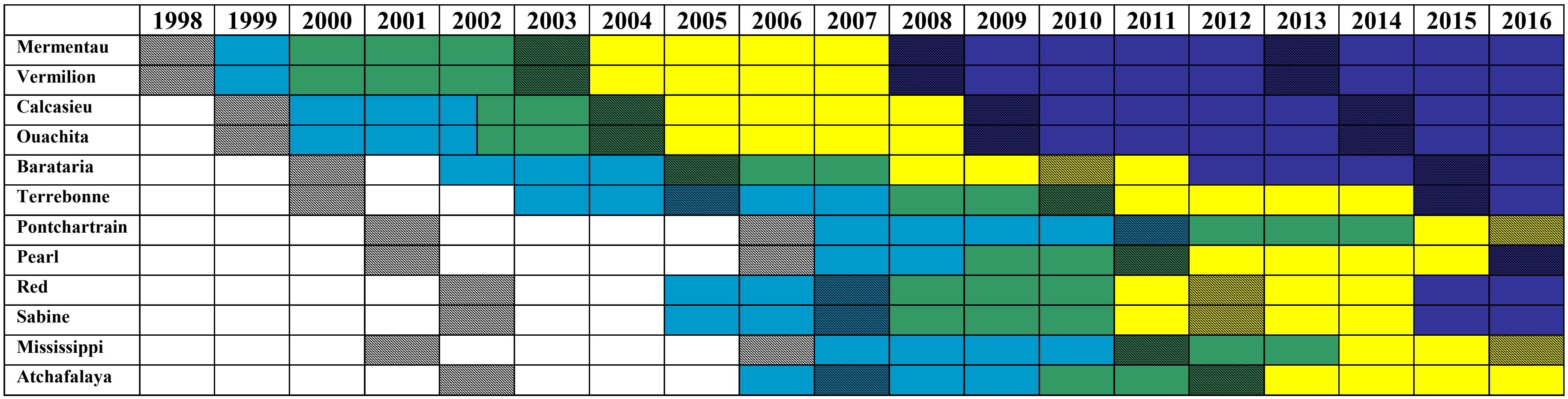


Figure 1a Shown above is the relative amount of various landuses in the watershed. Forested areas compose the largest portion of the land area in the watershed. The trees are cultivated for eventual harvest. Pasture grazing land follows silviculture for the second largest use in the watershed.

Timeline for Watershed Planning and Implementation



1- Black Stripes = Collect Water Quality Data to Develop Total Maximum Daily Loads (TMDLs) and to Track Water Quality Improvement at the Watershed Level **[Objective 1**]
2- Light Blue = Develop Total Maximum Daily Loads for the Watersheds on the 303(d) List [**Objective 2]**
3- Green = Develop Watershed Management Plans to Implement the NPS Component of the TMDL **[Objective 3]**
4- Yellow = Implement the Watershed Management Plans **[Objectives 4-8]**
5- Dark Blue = Develop and Implement Additional Corrective Actions Necessary to Restore the Designated Uses to the Water Bodies **[Objective 9-10**

FIGURE 1.1 Timeline for State-wide completion of TMDLs and Implementation Plans.

Table 2.1 The Attainable and Designated Uses of the Little River are the numerical criteria to insure Louisiana's waterways maintain safe levels for human health, propagation of fish and wildlife, and maintenance of recreational uses. As you can see from the table below, the Little River is meeting criteria for primary and secondary recreation and not meeting the criteria for the propagation of fish and wildlife (DO standards).

Use Attainability and Designated uses of the Little River

Waterbody	NPS related parameters for which numerical standards have been developed	Standard (From LDEQ Environmental Regulatory Code)	Does waterbody meet standard? (From 2000 305(b) Report)	Constituents for which TMDLs will be developed (From 1998 Court Ordered 303(d) list) [3]
Little River Subsegment 030804	Primary Contact Recreation	[1]	Fully	
	Secondary Contact Recreation	[2]	Fully	
	Dissolved Oxygen	5 mg/l- 3mg/l	Not	Low Dissolved Oxygen and Organic Enrichment
	Total Dissolved Solids	500 mg/l	Fully	
	Temperature ºC	32	Fully	
	Turbidity	150	Fully	
	Total Suspended Solids	500	Fully	

[1] Based on a minimum of not less than five samples taken over not more than a 30-day period. Fecal coliform count should be less than 200 /100ml over a 30-day period, and less than 10 % of samples during any 30-day period or 25 % of total samples collected annually can exceed 400/100ml. Applies only May 1 – Oct. 31, otherwise, criteria for secondary contact recreation applies.

[2] Based on a minimum of not less than five samples taken over not more than a 30-day period Fecal coliform count should be less than 1000 /100ml in at least 5 samples taken over a 30-day period, and less than 10 % of samples during any 30-day period or 25 % of total samples collected annually can exceed 400/100ml.

[3] It should be noted that TMDL listings were based on information dating back to 1992. A waterbody may meet standards for a particular constituent in the 2000 305(b) Report, but may require a TMDL due to failure to meet standards in a previous year. In addition, a waterbody may be listed due to its failure to meet certain narrative criteria.

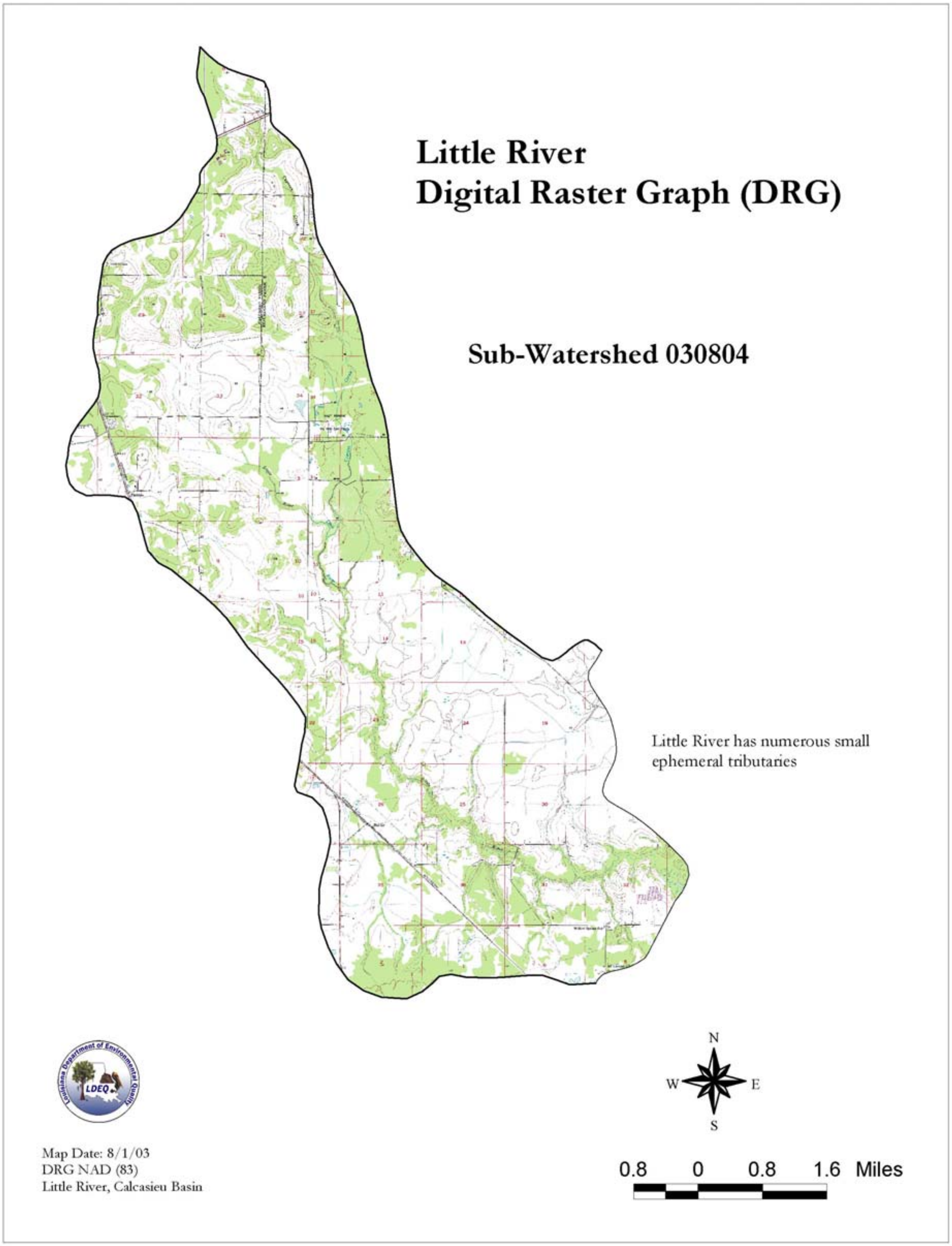


Figure 1.2 DRG of Little River watershed.

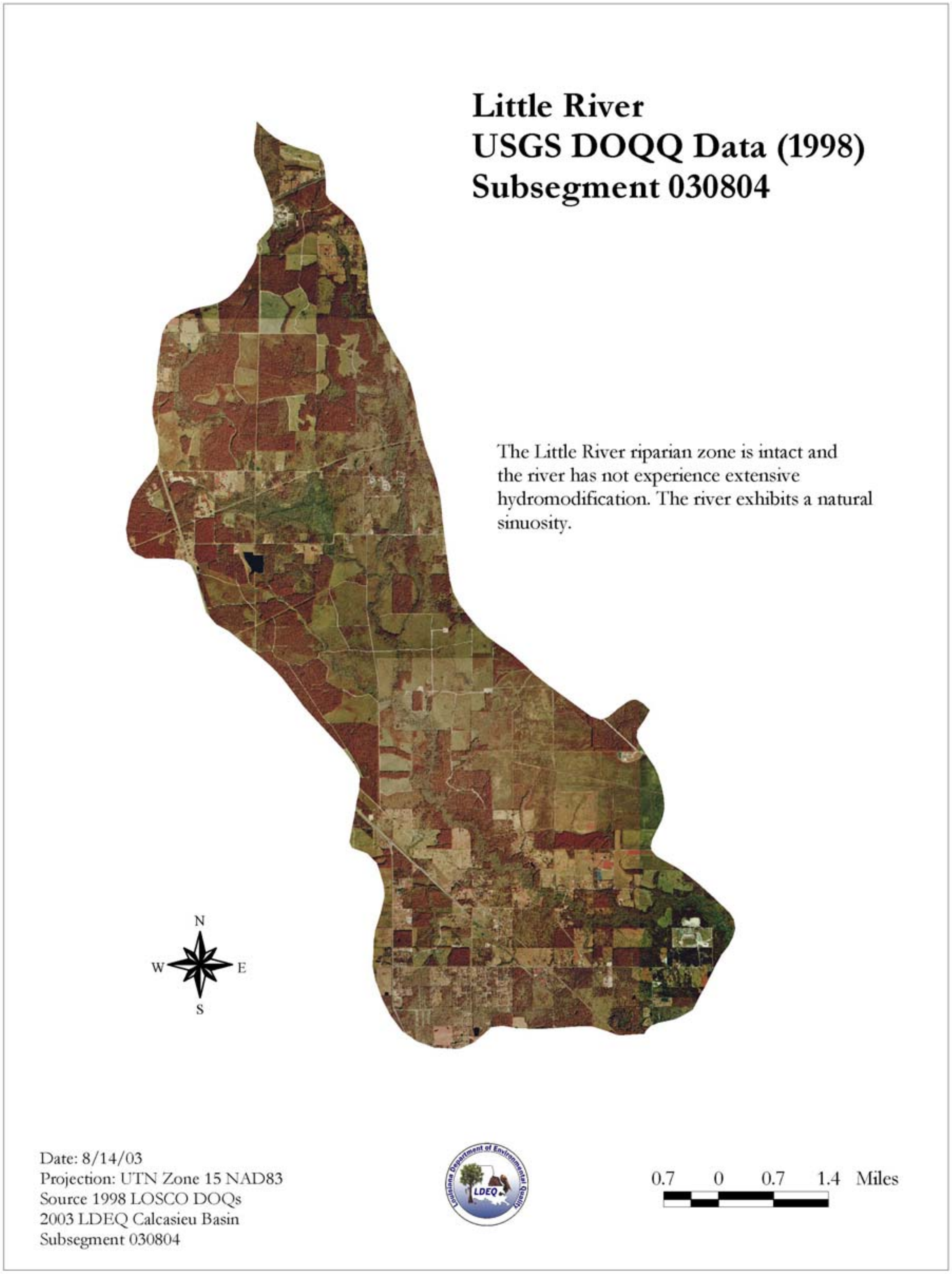


Figure 1.3 DOQQ of the Little River watershed.

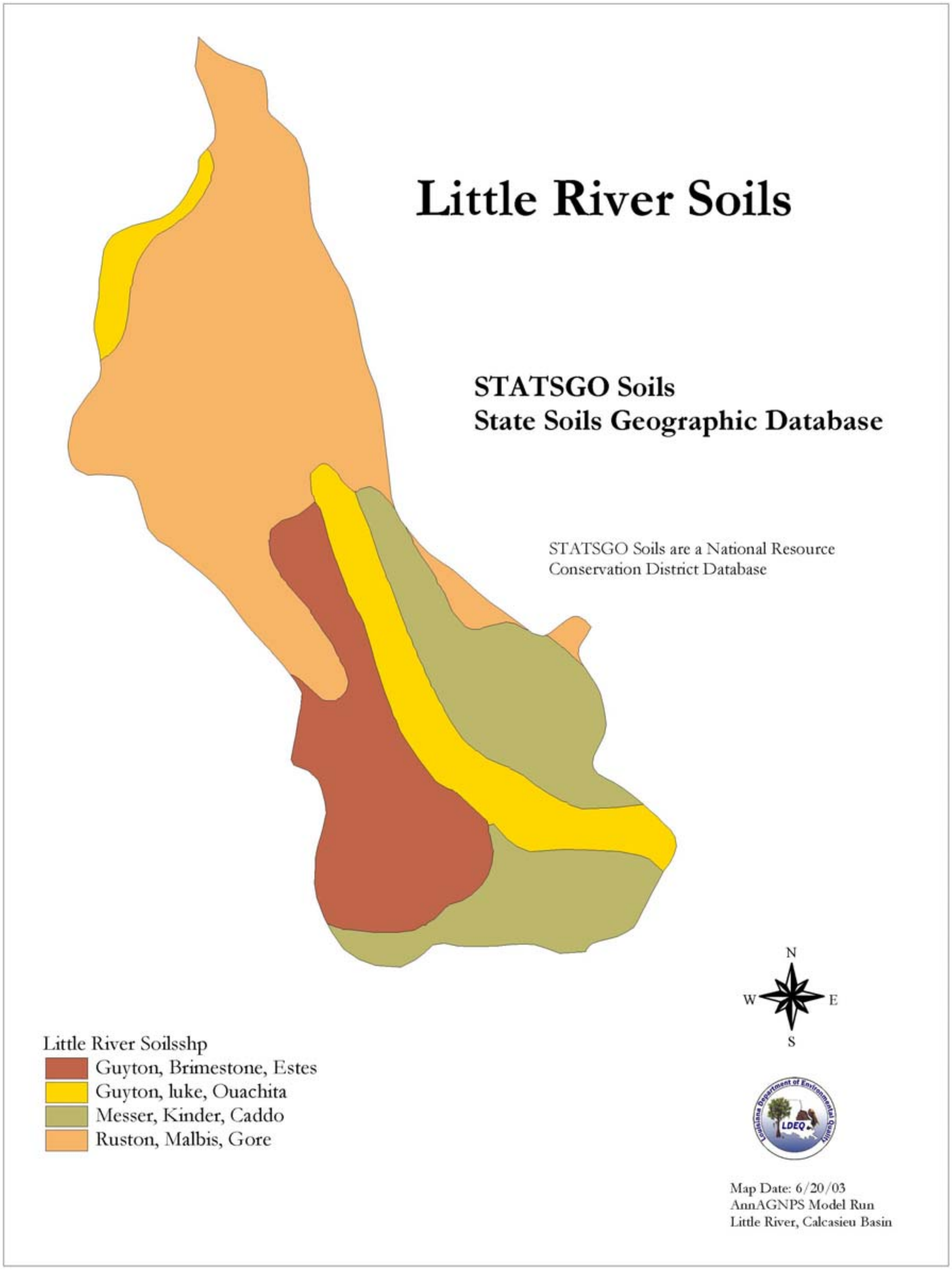


Figure 1.4 Soils map of the Little River watershed.

2.0 HISTORICAL ENVIRONMENTAL WATER QUALITY MONITORING IN THE LITTLE RIVER

2.1 INTRODUCTION

Only 1 year of ambient water quality data (1999) has been collected on the Little River at LDEQ monitoring site 58010844. The data shows that ambient conditions did not meet DO water quality criteria for both winter (5.0 mg/l) and summer (3.0 mg/l). Both 1999 and 2000 were a drought years in the watershed. The data below does not represent normal conditions. As mentioned before, the whether during these years was sub-critical, i.e. the 7 hottest and driest days over a normal 10 yr period. Only 2 of the 12 samples met criteria for DO. LDEQ will revisit the Little River in 2004 to conduct ambient water quality monitoring and reevaluate whether the stream system is impaired.

Ambient Water Quality Data 1999 at Little River East of Buhler, LA (Site 58010944)

Month	Temperature	Dissolved oxygen	Total dissolved solids	Total suspended solids	NO2 Nitrate	Total Kjeldahl nitrogen	Total Phosphorus	Total organic carbon	Turbidity
	Centigrade	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	NTU
December-99	8.42	4.86	96	8	0.02	0.71	0.13	17.3	5.7
November-99	16.94	3.81	107	9.5	0.02	0.66	0.08	18.4	5.3
October-99	11.8	6.06	108	4	0.02	0.88	0.09	17.85	6
September-99	24.07	2.21	91	14	0.03	1.04	0.14	16.7	13
August-99	25.9	2.51	212	32	0.05	1.77	0.22	16.4	96
July-99	26.18	0.65	153	4	0.04	1.24	0.15	24.4	27
June-99	24.62	0.79	284	4	0.03	1.48	0.1	32.9	22
May-99	23.01	0.11	160.1	14	0.02	1.73	0.15	24.2	14
April-99	23.31	2.09	136	21	0.05	1.85	0.17	25.1	20
March-99	16.19	2.41	138	7	0.02	0.92	0.16	17.1	32
February-99	11.42	4.9	312	16	0.06	1.3	0.11	16.1	50
January-99	11.81	5.76	180	12.5	0.02	1.05	0.14	17.1	40
Criteria	34 Centigrade	3mg/l summer 5mg/l winter	500 mg/l	NA	Naturally occurring range [1]			NA	150 NTU

[1] The naturally occurring range of nitrogen-phosphorus ratios shall be maintained. Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with designated uses shall not be added to any surface waters. LAC 33:IX.1113.8

2.2 WATER QUALITY DATA FROM LONG –TERM STATION

Since there is only 1 year of water quality data in the Little River Basin, some historical perspective on water quality in the area can be obtained from an LDEQ ambient monitoring site close by that has been in service since 1971. The data from all sites and all years reveals some characteristic seasonal trends. From March to August dissolved oxygen values decline and appear to correspond to increasing water temperature. The turbidity data was similar to what one might expect with higher values during the winter and spring months and dropping off in the summer through the fall, possibly corresponding to rainfall events and field activity. Whereas April does not seem to show a spike or elevated level for turbidity, it did seem to have a higher value for TKN, nitrate/nitrite and TP that may be related to rice discharge or fertilization of crops, forests, and lawns. Water clarity, as measured by the secchi disk, seemed to also exhibit a seasonal pattern of lower clarity during the winter and spring months and higher clarity during the summer and fall months. Total organic carbon appears to have a seasonal pattern similar to the TSS pattern. TDS trends probably result from saltwater intrusion or increased salinities during the fall months.

Overall, water quality seems a little better in the upper Calcasieu than in the lower Calcasieu and the tributaries. The median values by month for the lower Calcasieu and the tributaries drop below the 5 ppm dissolved oxygen standard, but the upper Calcasieu does not. A saltwater intrusion barrier separating the upper and lower Calcasieu can account for the higher TDS values in the lower Calcasieu than in the tributaries or in the upper Calcasieu.

In general, nutrient values are consistently higher in the lower Calcasieu and the tributaries. The lower Calcasieu and tributaries drain areas that are primarily pastureland, forested, or urban with the city of Lake Charles comprising a large portion of this area. The peak in nutrients, such as nitrate/nitrite, that occurs in April is possibly a result of the fertilization of lawns, forests, or pasture, which is often done during the spring. The turbidity pattern is also interesting with the lower Calcasieu and the tributaries peaking in April and the upper Calcasieu values exceeding them in June through November.

Annual trends do not appear as prevalent as seasonal trends, but it appears that the median values for both the upper and lower Calcasieu met the D.O standard for all years, and only the tributaries did not. (See Appendix A for map and graphs of water quality data and monitoring sites)

2.3 Temperature is Inversely Proportional to Dissolved Oxygen

Another clear trend in the historical results is the relationship of DO levels to temperature. Biochemical reactions, in general, follow the van't Hoff rule of a doubling of the reaction rate for a 10°C increase in temperature over a restricted temperature range. Therefore, temperature is strongly inversely proportional to dissolved oxygen levels. July and August are the hottest months in Louisiana, while October and November are the months with lowest stream flows. Dissolved oxygen and runoff are moderately directly proportional. The TMDL analysis concluded that critical conditions for stream DO concentrations were those of negligible nonpoint run-off and low stream flow combined with high stream temperature. When the rainfall and stream flow are high, turbulence is higher due to higher flow and the temperature is lowered due to rainfall run-off. Reaeration rates are much higher when water temperatures are cooler and BOD decay rates are much lower. For these reasons, periods of high loadings are periods of higher reaeration and DO but not necessarily periods of high BOD decay. LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for accumulated benthic blanket in the stream, which is expressed as SOD or re-suspended BOD. This accumulated loading (SOD) has its greatest impact on the stream during periods of higher temperature and lower flow.

3.0 BASIN AND ECO-REGION

3.1 CALCASIEU RIVER BASIN

The Calcasieu River Basin is located in southwestern Louisiana. It begins in the hills west of Alexandria, LA and flows south for approximately 257.44 km (160 miles) to the Gulf of Mexico. The mouth of the river is approximately 48.27 km (30 miles) east of the Texas-Louisiana state border. (LA DEQ, 1996). The basin encompasses the hill region of the state, the terrace region, and a section of the coastal marsh. The upper end of the basin consists of pine forested hills, while the lower end of the basin consists of brackish and salt marshes. Originally, much of the area was covered by tall prairie grasses, among which there were scattered clumps of trees.

The hill region includes the longleaf pine forests, maximum elevations and relief, dendritic and trellis drainage, interior salt domes, wolds or cuestas (hard sedimentary rock), ironstone, excellent surface and groundwater resources, mature soils and the oldest rocks in the state. The soil types consist of coastal plain soils and flatwoods soils. Vegetation includes longleaf pine forests (longleaf pines, slash pines, some hardwoods) and bottomland hardwoods (cottonwood, sycamore, willow, water oaks, gum, maple, loblolly pine).

The terrace region includes intermediate elevations and relief, older alluvium, and a large percentage of tabular surfaces. The terraces range from flatwoods to prairies. The flatwoods consist of low relief, mixed longleaf forests, bagols, pimple mounds, dendritic drainage, flatwoods soils. Vegetation includes flatwoods (longleaf pine, oak, palmetto, wiregrass), cypress forests (cypress, tupelo), and bottomland hardwoods. The prairies consist of low relief, prairie grassland, prairie soils, pimple mounds, dendritic streams, ice-age channels, and platin or marais (small, shallow undrained ponds in the prairies). Vegetative cover consists of prairie vegetation (bluestem, broomsedge), cypress forests, and bottomland hardwoods.

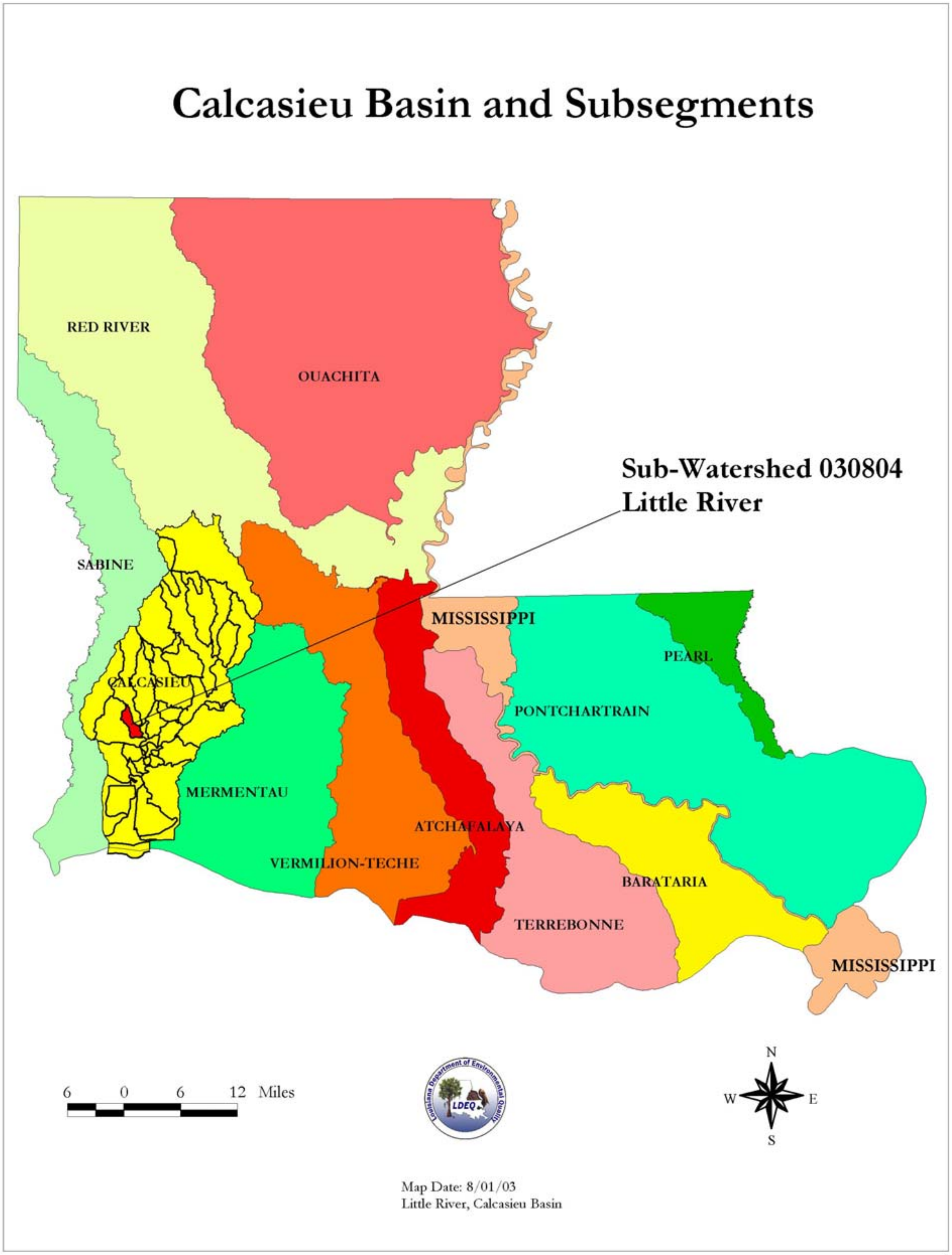


Figure 3.1 Map of Calcasieu River Basin and Little River Subsegment.

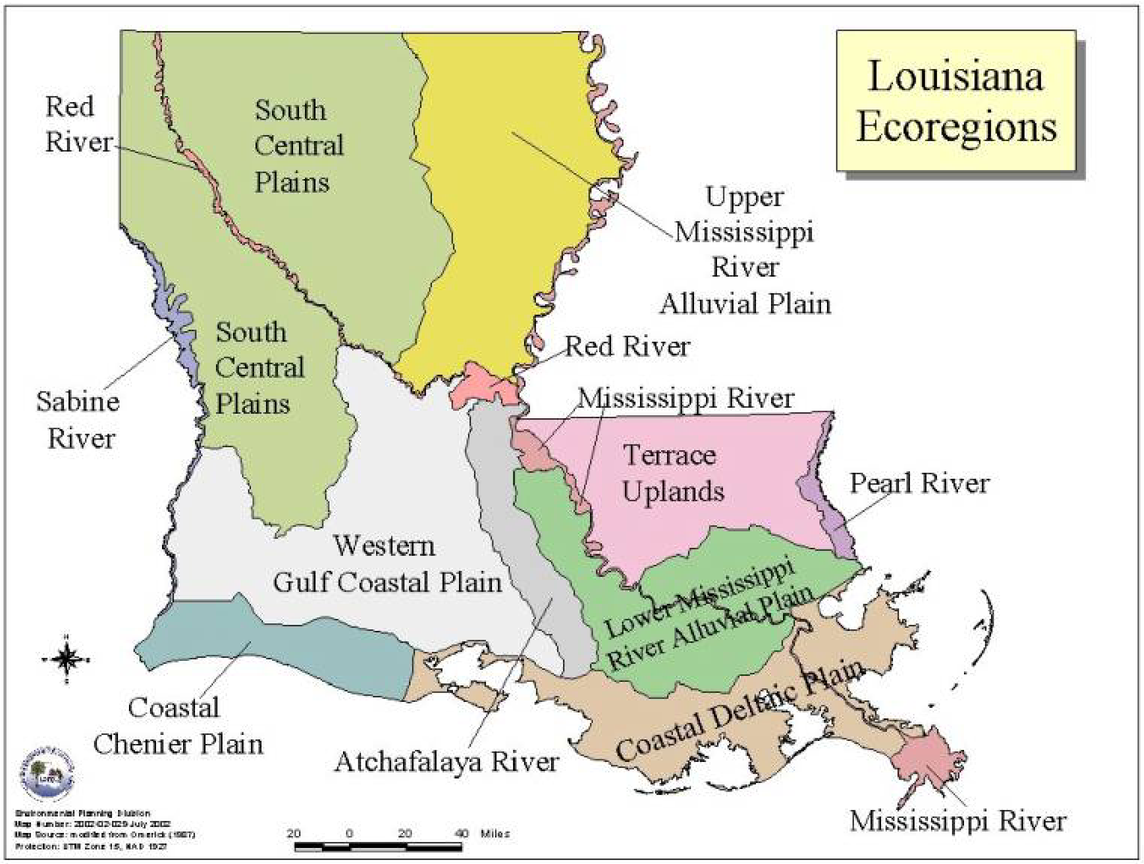


Figure 3.2 The State of Louisiana is divided into 12 Eco-Regions characterized by unique soils, fauna, and agricultural crops. The Little River is located in the Western Gulf Coastal Plains.

3.2 DESCRIPTION OF LOUISIANA ECO-REGIONS

Little River is located within Western Gulf Coastal Plain Ecoregion (WGCPE) in Southwest Louisiana. The WGCPE is bounded to the north by the South Central Plains Ecoregion, to the south by the Intracoastal Waterway, to the west by the Sabine River, and to the east by the Atchafalaya River. The ecoregion includes portions of the Sabine, Calcasieu, and Vermilion basins. Drainage basin boundaries and downstream estuarine waters isolate the four major river systems within the ecoregion. The ecoregion lies above tidal areas, except under extreme drought conditions; therefore, tidal influences areas aregenerally excluded. Although there are several types of vegetation present in the northern area of the ecoregion, 60 – 70% of the WGCPE has historically been a seasonally wet prairie. The prairie was maintained as a mosaic of treeless plains and tree lined river corridors by the presence of an impermeable, calcareous clay layer that prevented downward percolation or upward capillary action of water into the shallow soils. Disjunction of this clay layer at stream margins allows trees to grow for a few hundred feet on either side of the stream. This clay layer allows water to stand during wet seasons, supporting the dominant land use of the area, rice cultivation.

4.0 POTENTIAL NONPOINT SOURCE (NPS) LOADINGS INTO THE LITTLE RIVER WATERWAYS

4.1 INTRODUCTION

Land uses such as pastureland, rural residential, forestry, and natural systems contribute to the loading of chemical, mineral, and biological elements to the waterways. Residential home sewage from faulty septic systems also contributes to the nutrient and organic loadings to the waterways. As shown in the table below, NPS pollutant loadings to the Little River are the result of four main sources: forestry, pasture, rural residential, and natural background. There are a few rural residential areas in the watershed; however, the majority of the land is used for silviculture. Discussed below are the suspect sources that contribute oxygen-demanding substances to the Little River and its tributaries.

4.2 FORESTRY

The primary NPS pollutant from silviculture operations is sediment. Other pollutants of concern include pesticides, herbicides, fertilizers, fire-retardant chemicals, organic matter and woody debris in the watercourses. Clear-cutting of trees and removal of riparian areas can cause significant NPS loading. Harvesting trees along watercourses also causes thermal pollution from lack of shading and increased water temperatures. Increased temperature reduces in-stream dissolved oxygen (DO). Without proper controls, local streams and waterways become impacted and water quality impaired.

Access roads, stream crossings, skid trails, shearing and windrowing are the type of forestry activities, which can generate the greatest NPS loading into local receiving streams. Excess sediment causes most of the NPS load. These activities disturb soils exposing them to wind and rain. When rains occur over exposed or disturbed soils, the impact from falling raindrops causes soil sediment particles to become dislodged. As the surface waters accumulate, the instable sediments become suspended, and then they are carried away by the runoff. As a result, there is sediment deposition in the lower elevations such as local wetlands, tributaries, and the bayou. This causes an NPS loading. Continued sediment runoff causes "aggradations", or filling of the stream. Waterways with shallow water depths have increased water temperatures, intermittent flows, and sunlight reaching bottom of stream. These conditions cause loss of DO from the local waterways. In some cases where fertilizers are used on forested lands, nutrient-rich surface runoff can occur. Nutrient enriched runoff from forested lands causes NPS loading, which consume in-stream dissolved oxygen. The most common nutrients are nitrogen and phosphorus. High in-stream nutrient concentrations can result in algae blooms and eutrophicated waters (no oxygen in the water).

Another significant impact to local streams caused by forestry activities that can produce an indirect NPS loading is "hydrologic changes" in the watershed. When forested lands are harvested, the native landscape becomes converted into an open land having less percolation and infiltration of rainfall. As a result, there are increased amounts of runoff and higher flow rates entering local receiving streams. Higher runoff velocities generate greater hydraulic energy, which destabilizes streambanks. Rushing waters cause "scouring" of streambanks. Accelerated bank erosion and bank scour produces an NPS loading. Common attributes of streams located within, and downstream of clear-cut forests are live fallen trees into the channel, scoured streambanks, and washouts. In-stream sediment deposition, or "aggradations" is another stream attribute of the areas. Unfortunately, these attributes are long lasting until the stream becomes stabilized again.

At this juncture, it is not known what percent of the anthropogenic loading silviculture is responsible for. As the TMDL clearly states: "the suspected sources of impairment is natural sources" and the stream is "naturally distrophic".

4.3 Pastureland

The second major landuse is grazing pasture. Rain events suspend sediments, fertilizers, and manure and the runoff to the reaches of the bayou. Runoff from fields soon after tillage operations, fertilizer applications, and other field operations contains greater levels of sediments and pollutants. The cumulative effect of agricultural nonpoint pollutants results in potentially damaging concentrations of nitrogen, phosphorus, sediments, turbidity, and pesticide residue in the water bodies. The primary mechanism to reduce the amount of sediment and nutrients entering the waterbody is for the farmers to adopt Best Management Practices (BMPs) in order to meet TMDL objectives for the watershed. LDEQ and NRCS composed a list of seven types of BMPs that can be utilized to reduce pastureland NPS loading.

4.4 Rural Residential

Rural residential areas compose 1% of the landuses in the watershed. Recent water quality monitoring studies in Rural Residential areas have shown that the highest pollutant loading and concentrations usually occur during rainfall events in the first runoff of rain, commonly referred to as the "first flush." When an area is developed by residential homes, impervious surface area such as streets, driveways, and rooftops, are increased. These smooth, impenetrable surfaces allow little or no detention or infiltration of stormwater. Pollutants that are present between rainfall events in the atmosphere prior to a storm and which accumulate on impervious surfaces are generally carried away. As precipitation falls on rural residential areas, it picks up contaminants from the air, littered and dirtied streets and sidewalks; petroleum residues from automobiles, exhaust products, heavy metals and tar residuals from the roads; chemicals applied for fertilization, weed and insect control; and, sediments from construction sites. The dumping of chemicals such as used motor oil and antifreeze into storm sewers is another source of rural residential NPS pollution. Home development can affect the hydrologic characteristics of watersheds as well. In undeveloped natural drainage areas, the volume and rate of stormwater runoff from a particular rainfall event is primarily determined by the natural detention and infiltration characteristics of the land, and is related to topography, soil types, and vegetative cover. With less detention and infiltration due to impervious surfaces, runoff volume increases, as well as, the rate of stormwater runoff. When streams overflow their banks, there is an increased opportunity for pollutants including trash and debris to enter the flow of water. Erosion of the stream channel represents a significant source of sediment pollution, and the loss of vegetation along stream banks reduces the pollutant assimilation capacity of a stream.

4.5 Home Sewerage

A significant portion of Louisiana's NPS pollution can be attributed to sewerage runoff from homes, camps, and businesses that are not connected to municipal sewerage treatment facilities. It is estimated that 1,323,600 people in Louisiana treat and dispose of their sewerage with individual waste disposal systems, and that over 50% of these systems are malfunctioning because of incompatible soil types or lack of maintenance. These failing systems are a major cause for water quality degradation in Louisiana's scenic streams and fresh water aquifers. Septic tank systems normally consist of two components, a treatment unit and a disposal unit. The septic tank and soil absorption system is the most common individual waste disposal system used in Louisiana. The purpose of the septic tank is to condition household wastes so that the discharge will readily percolate into the soil. This conditioning is done in a septic tank by the removal of solids by settling and also by decomposition of the soluble organics. The soil then provides additional treatment by the removal of bacteria, organics, and nutrients. One of the main problems with using conventional septic tank soil absorption systems in Louisiana is that 87 percent of the soil associations in Louisiana are considered inadequate for conventional septic tank systems as determined from the Soil Limitation Ratings for Sanitary Facilities. Another major component to the pollution caused by septic tank systems is inadequate enforcement of the State Sanitary Code. A properly designed septic tank consists of a buried, watertight, multiple compartment tank, usually of concrete material, equipped with inlet and outlet devices and scum control baffles.

5.0 Physical, Chemical, and Biological Causes for Oxygen Depletion

5.1 Sediment Oxygen Demand and Reaeration

The slope of the Little River is very gradual and the potential for reaeration is low. The bayou is slow moving and depositional in nature, resulting in continued sedimentation within the streambed. The watershed rests on an alluvial plain where soils are composed of silty loams and clays (see soils map). Organic matter attaches to the clay and silts and creates an oxygen demand as the particles decompose within the waterway. After time, this process results in a layer of muck along the streambed. This layer of muck creates what is commonly referred to as sediment oxygen demand (SOD). Agriculture is the largest contributor to the accumulation of sediments and nutrients to the waterway. Rain events suspend exposed soils and fertilizers, transport them overland, and deposit them in the bayou. Nutrients encourage the growth of aquatic plants and nitrifying bacteria. Respiration consumes DO and the decomposition of the organisms contributes to SOD and/or eutrophication. Sediment oxygen demand is the amount of oxygen consumed by the bacteria as they attack the organic material that has settled or been captured to form a sediment or sludge deposit. Composed largely of particles of organics attached to sediments, feces, dead algae, and decaying plant matter, the accumulated sediments can dominate oxygen dynamics. Both winter and summer fish-kills in natural systems, caused by oxygen depletion, can be attributed to oxygen consumption by the sediments.

5.2 CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND

The waterways contain particulate or dissolved organic materials that can serve as food for heterotrophic bacterial communities, which in turn consume large amounts of oxygen. The potential impact of these dissolved organics on the water's oxygen supply is estimated by measuring the water's carbonaceous biochemical oxygen demand (CBOD). The CBOD of a sample is measured by observing the oxygen drop in a sealed bottle over a fixed number of days (usually five). The number of days used in the test is indicated by a suffix, i.e., CBOD5. A high CBOD5 (>15 mg/l) implies that a lot of bacterial activity will occur in the water throughout the day and night as the bacteria attack the suspended or dissolved organics.

5.3 NITROGENOUS BIOCHEMICAL OXYGEN DEMAND

The nitrogenous biochemical oxygen demand (NBOD) is a major cause of oxygen loss in aquatic systems. NBOD is a measure of the amount of oxygen that is consumed by the nitrifying bacteria as they convert total ammonia nitrogen (TAN) to nitrate. Approximately 4.57 milligrams of oxygen are consumed for each milligram of TAN converted to nitrate nitrogen. TAN is directly excreted into the water by a wide variety of aquatic organisms and is very difficult to remove without bacterial activity. Unless the water is rapidly flushed, the water's NBOD must be satisfied within the system. TAN is also produced as a by-product of the decay of sediments and sludges as the bacteria break down proteins and amino acids to form ammonia.

5.4 HIGH TEMPERATURES AND LOW FLOW

Biochemical reactions, in general, follow the van't Hoff rule of a doubling of the reaction rate for a 10^{o}C increase in temperature over a restricted temperature range. Therefore, temperature is strongly inversely proportional to dissolved oxygen levels. July and August are the hottest months in Louisiana, while October and November are the months with lowest stream flows. Dissolved oxygen and runoff are moderately directly proportional. The TMDL analysis concluded that critical conditions for stream DO concentrations were those of negligible nonpoint run-off and low stream flow combined with high stream temperature. When the rainfall and stream flow are high, turbulence is higher due to higher flow and the temperature is lowered due to rainfall run-off. Reaeration rates are much higher when water temperatures are cooler and BOD decay rates are much lower. For these reasons, periods of high loadings are periods of higher reaeration and DO but not necessarily periods of high BOD decay. LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for accumulated benthic blanket in the stream, which is expressed as SOD or re-suspended BOD. This accumulated loading (SOD) has its greatest impact on the stream during periods of higher temperature and lower flow. NPS pollutant loadings, primarily silviculture and natural loading from forested riparian areas, are the major source of this SOD in the Little River watershed.

6.0 WASTE LOAD ALLOCATION

6.1 POINT SOURCE DISCHARGES IN LITTLE RIVER

There are no known dischargers in the watershed.

6.2 TMDL BOD LOAD IN LITTLE RIVER

This section describes how LDEQ determined the TMDL for the waterbody. The TMDL instream model (LA QUAL) describes the amount and distribution of oxygen demanding materials or biological oxygen demand (BOD) in the waterway. The ultimate BOD (UBOD) includes both the nitrogen (NBOD) and carbon (CBOD) based forms of BOD. LDEQ models for critical conditions called the 7Q10, which are the 7 consecutive lowest flow days from a 10-year period. The LA QUAL model partitions the BOD load to several different sources and divides the bayou into stream reaches from the headwaters to the end of the waterbody. LDEQ collects water quality samples along the waterway to establish a BOD load and to calibrate the model. Once the total BOD load is determined, it is partitioned into point sources and NPS sources, plus a margin of safety is factored in to accommodate any potential errors. Point sources require a LPDES discharge permit, which identifies its location and sets a limit on the amount of BOD load that can be discharged out the end of the pipe. The modelers are able to subtract the point source load from the measured and modeled total BOD load. The rest of the BOD load is either assigned to natural or manmade NPS pollution. In the Little River, there are no known discharges so all the BOD loading is assigned to NPS sources.

The TMDL segregates the remaining pollutant load into 4 categories: Benthic Load (Sediment Oxygen Demand (SOD) and Nonpoint), Waste Load (point sources), Headwaters and Tributary Load, and Incremental (groundwater, runoff, and small tributaries). Also, the model can account for headwaters if there are any in the stream system. Therefore, the model distributes BOD loads by stream reach and then estimates whether the pollutant load is SOD, Incremental, or Man-made Nonpoint.

6.3 LA QUAL MODELING RESULTS

The TMDL survey was conducted during a drought year during sub-critical conditions. Such conditions make the stream network more difficult to model. Nevertheless, in the following tables, the total BOD and partitioned BOD loads are distributed by reach, beginning at the top of the watershed. The values are the results of calibrated data during 7Q10 periods, which represents the amount of suspended and benthic materials present in the bayou at the time of sampling. It should be noted that since samples were collected during low flow conditions, they represent only a portion of the pollutant load delivered to the bayou. It is what remained in the bayou during the lowest flow conditions. The sediment oxygen demand (SOD) portion of the total load, is defined as the oxygen demand exerted by the bottom sediments.

The following tables and charts indicate where the BOD load resides. As you can see, the BOD load tends to increase towards the bottom of the watershed. One reason that BOD materials collect and reside towards the lower end of the watershed is because of the channel slope. The sediments and the BOD load will collect where the bayou levels out until a large rain event produces enough hydraulic head to push the material down stream eventually into the Gulf of Mexico. The BOD increases towards the bottom of the bayou due to lack of slope.

6.4 TMDL MODEL REACHES

The bayou was sub-divided into 19 separate reaches during the development of the TMDL. Nonpoint loading values for each of these reaches have been calculated using the calibration data from the TMDL model.

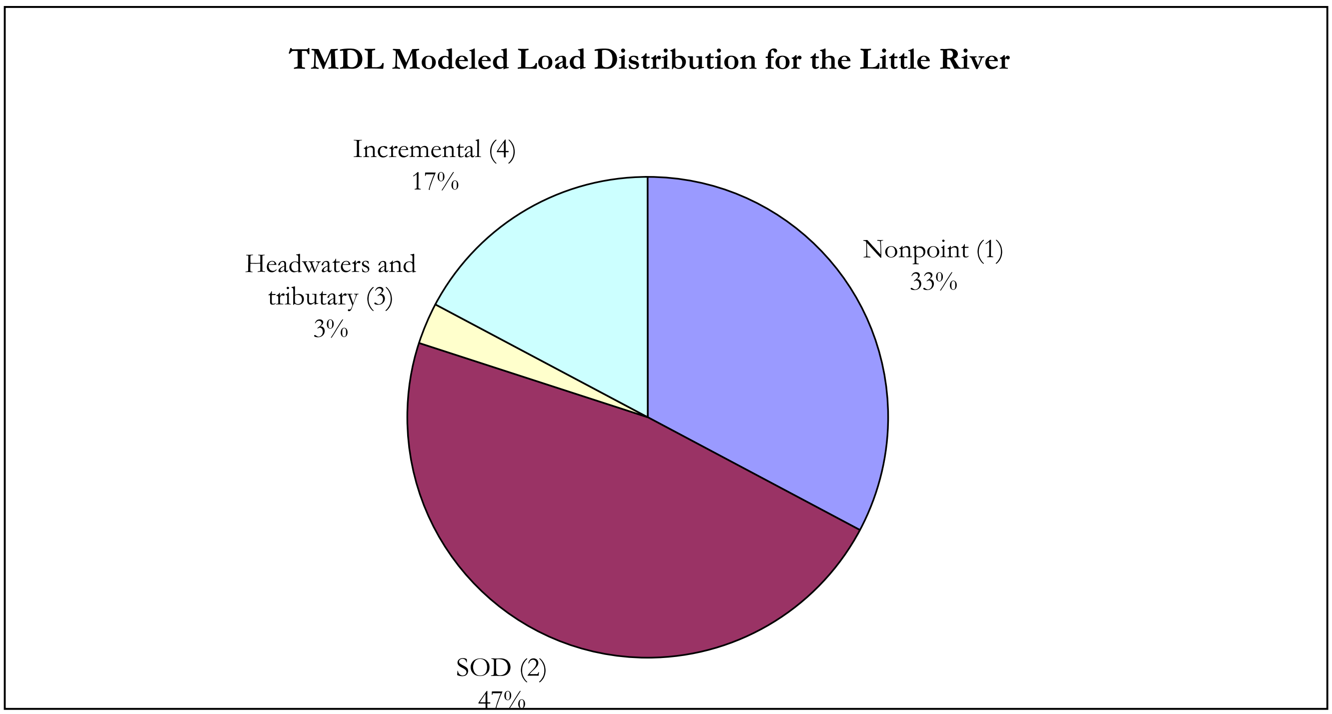


Figure 6.1: The TMDL model segregates stream pollutant loads into 4 catagories:
(1) Nonpoint load are the materials suspended in the water column.
(2) Sediment oxygen demand (SOD) is the benthic load that resides on the stream bottom.
(3) Headwaters and tributaries are the loading from tributaries and headwater.
(4) Incremental load includes ground water, NPS from rain events, and tributaries.

Table 6.1

Little River TMDL Load by Reach and Description of Reach

Reach Identification			Reach Description				BOD Load by Reach				BOD Load by River Kilometer				
Reach #	Reach ID	Reach Name	Beginning of reach (km)	End of reach (km)	Width of reach (m)	Length of reach (km)	Nonpoint load (kg/day)	SOD load (kg/day)	Incremental load (kg/day)	Headwaters and Tributaries (kg/day)	Nonpoint load (kg/day/river km)	SOD load (kg/day/river km)	Incremental load (kg/day/river km)	Headwaters and Tributaries (kg/day/river km)	Total Loading by kg/day/river km
1	LR	Holdbrook Park Rd-Cypress Creek	19.5	17.7	1.3	1.8	1.3	6.3	0.0	24.5	0.7	3.5	0.0	13.6	17.9
2	LR	Cypress CRK-UnNamed trib	17.7	16.1	1.7	1.6	2.3	7.6	4.0	0.0	1.4	4.2	2.2	0.0	7.9
3	LR	UT (LDB) Site 4.0	16.1	15.9	2.4	0.2	0.0	1.4	0.6	0.0	0.0	0.8	0.3	0.0	1.1
4	LR	Site 4.0-UT (RDB)-	15.9	14.7	2.4	1.2	0.0	8.2	19.2	0.0	0.0	4.5	10.7	0.0	15.2
5	LR	UT (RDB)-UT(LDB)	14.7	13.6	3.0	1.1	0.0	9.9	17.6	0.0	0.0	5.5	9.8	0.0	15.3
6	LR	UT (LDB)-UT (RDB)	13.6	12.5	3.8	1.1	0.4	10.3	17.6	0.0	0.4	5.7	9.8	0.0	15.9
7	LR	UT (RDB)-UT(LDB)	12.5	11.1	4.5	1.4	0.6	34.7	22.4	0.0	0.4	19.3	12.5	0.0	32.1
8	LR	UT (LDB)-RKM 10.5	11.1	10.5	5.3	0.6	0.6	17.3	9.6	0.0	1.0	9.6	5.3	0.0	16.0
9	LR	RKM 10.5- RKM 9.5	10.5	9.5	6.0	1.0	0.6	27.0	16.0	0.0	0.6	15.0	8.9	0.0	24.5
10	LR	RKM 9.5-UT (RDB)	9.5	8.5	6.8	1.0	4.8	30.4	16.0	0.0	4.8	16.9	8.9	0.0	30.6
11	LR	UT RDB-UT (LDB)	8.5	7.8	7.5	0.7	4.8	20.0	11.2	0.0	6.9	11.1	6.2	0.0	24.2
12	LR	UT LDB - UT RDB	7.8	6.6	8.3	1.2	6.4	37.6	19.2	0.0	5.3	20.9	10.7	0.0	36.9
13	LR	UT RDB -Site 3	6.6	6.2	8.7	0.4	6.0	13.2	6.4	0.0	15.0	7.3	3.6	0.0	25.9
14	LR	Site 3 -RKM 5.0	6.2	5.0	8.7	1.2	32.2	37.5	0.0	0.0	26.8	20.9	0.0	0.0	47.7
15	LR	RKM 5.0- RKM 4.0	5.0	4.0	9.9	1.0	47.2	30.7	0.0	0.0	47.2	17.1	0.0	0.0	64.3
16	LR	RKM 4.0-RKM 3.0	4.0	3.0	12.1	1.0	52.0	32.7	0.0	0.0	52.0	18.2	0.0	0.0	70.2
17	LR	US of Cecos-Camp-site 2	3.0	1.7	14.3	1.3	73.0	46.5	0.0	0.0	56.2	25.9	0.0	0.0	82.0
18	LR	Site 2-DS of Cescos	1.7	1.0	14.3	0.7	36.0	25.1	0.0	0.0	51.4	13.9	0.0	0.0	65.4
19	LR	US of Confluenc w/W. Fork cal	1.0	0.0	16.5	1.0	36.0	41.3	0.0	0.0	36.0	22.9	0.0	0.0	58.9
Totals							304.2	437.[illegible]	159.9	24.5					

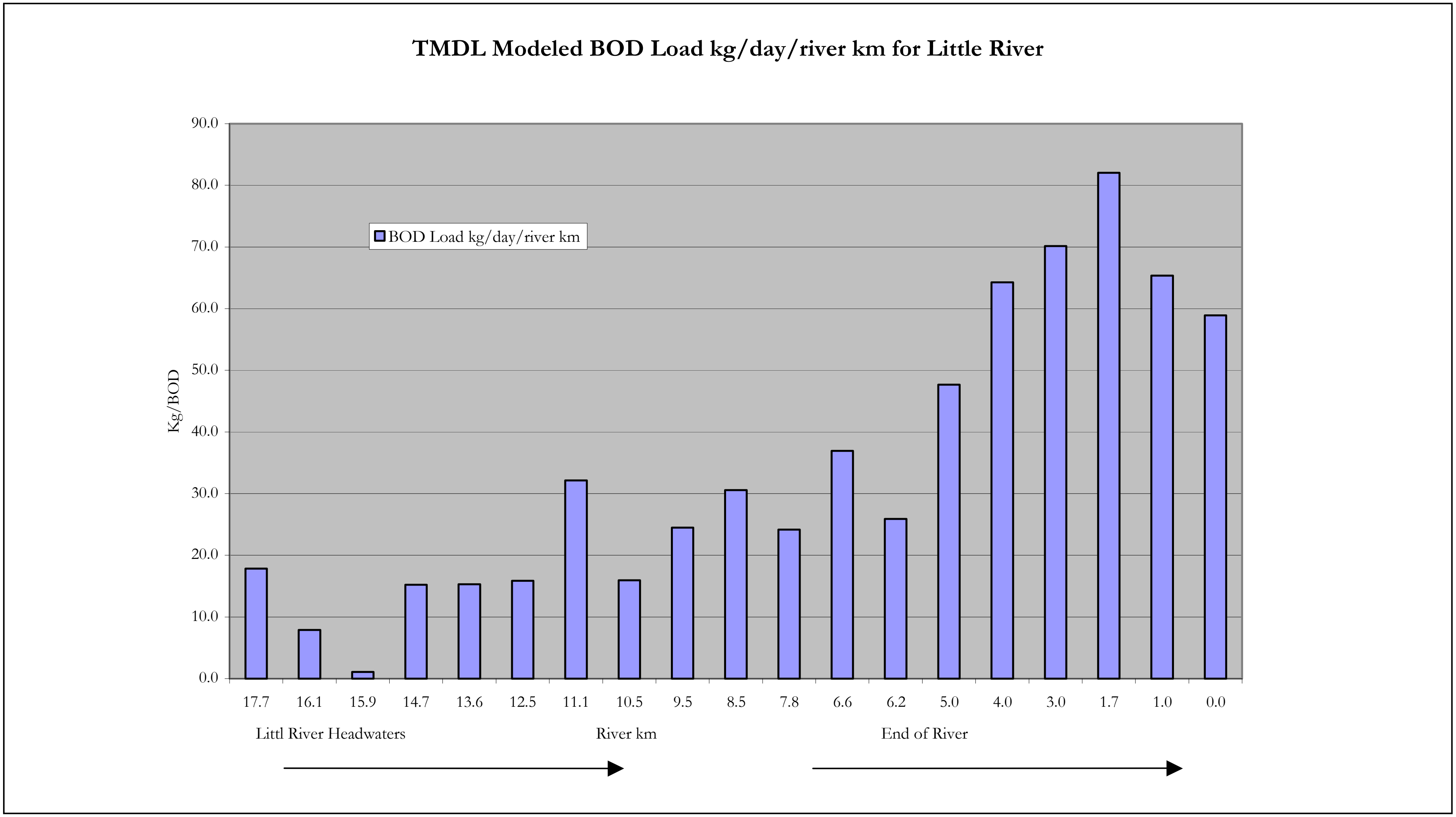


Figure 6.1 The bar Chart above shows the TMDL modeled BOD load by river km along the Little River stream network.

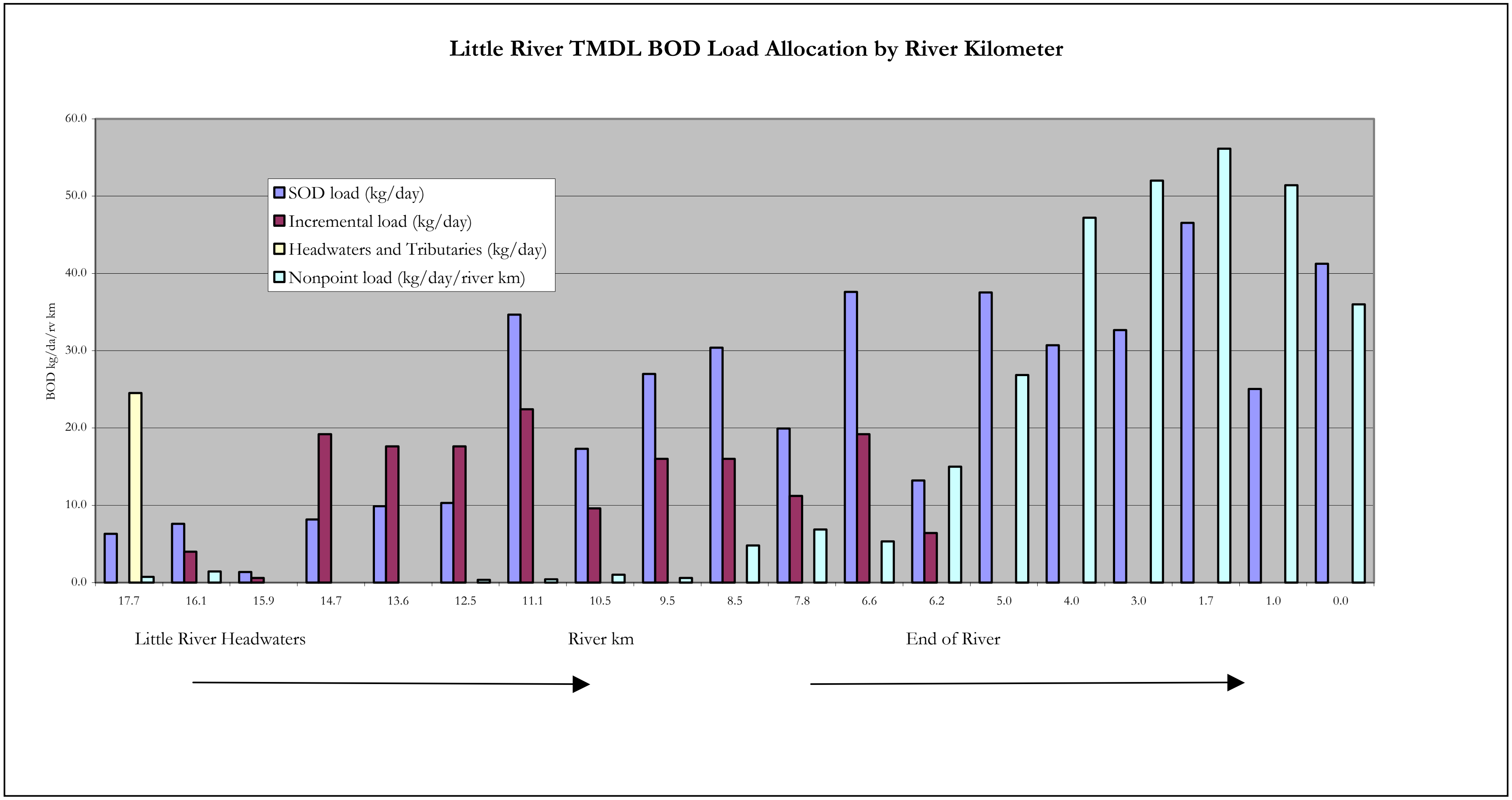


Figure 6.2 This chart segregates the TMDL modeled BOD load into 4 categories. See figure 6.1 for a description of each of the sources of BOD.

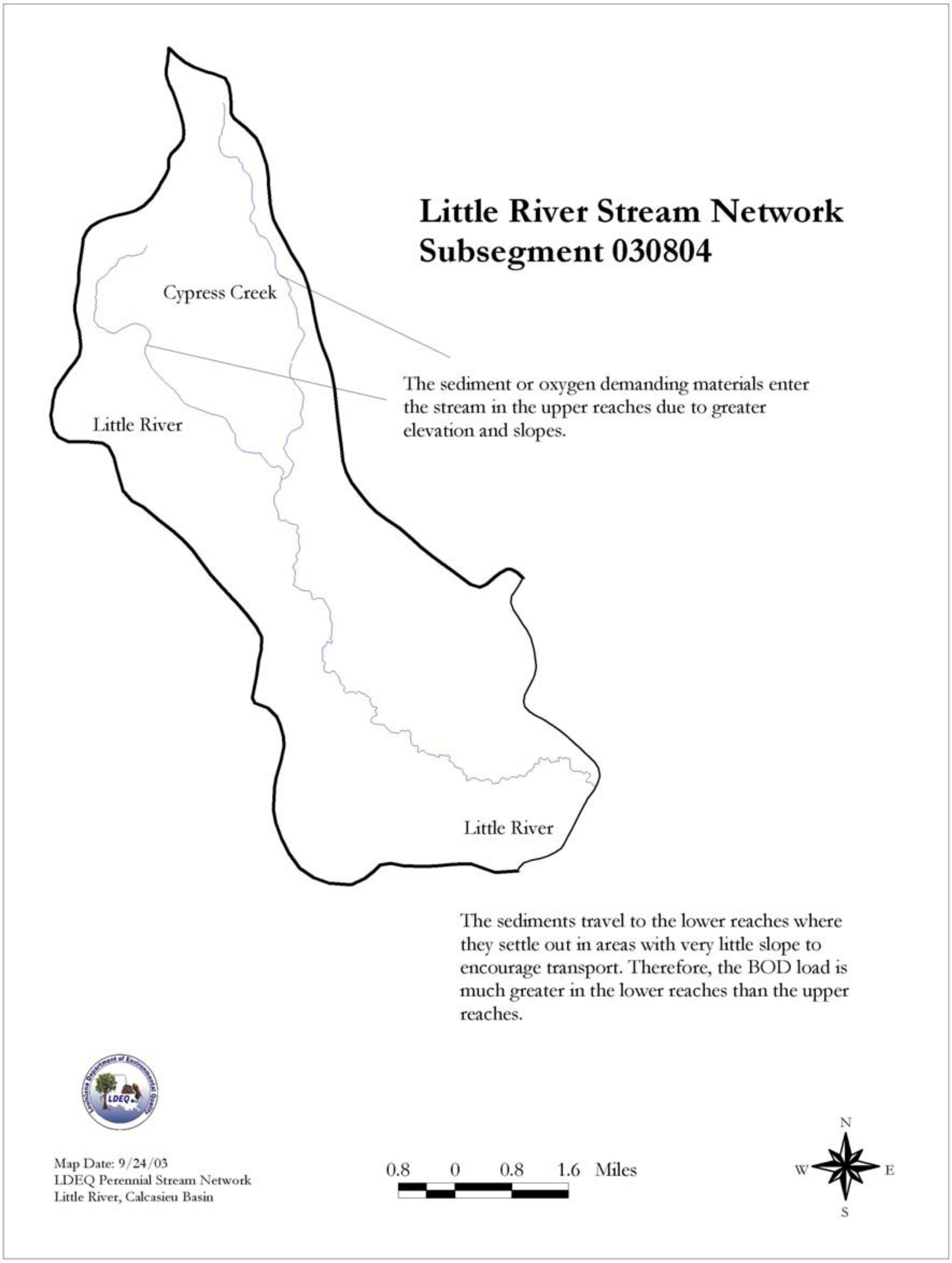


Figure 6.3 Little River stream system.

7.0 ANNUALIZED AGRICULTURE NONPOINT SOURCE MODEL (ANNAGNPS)

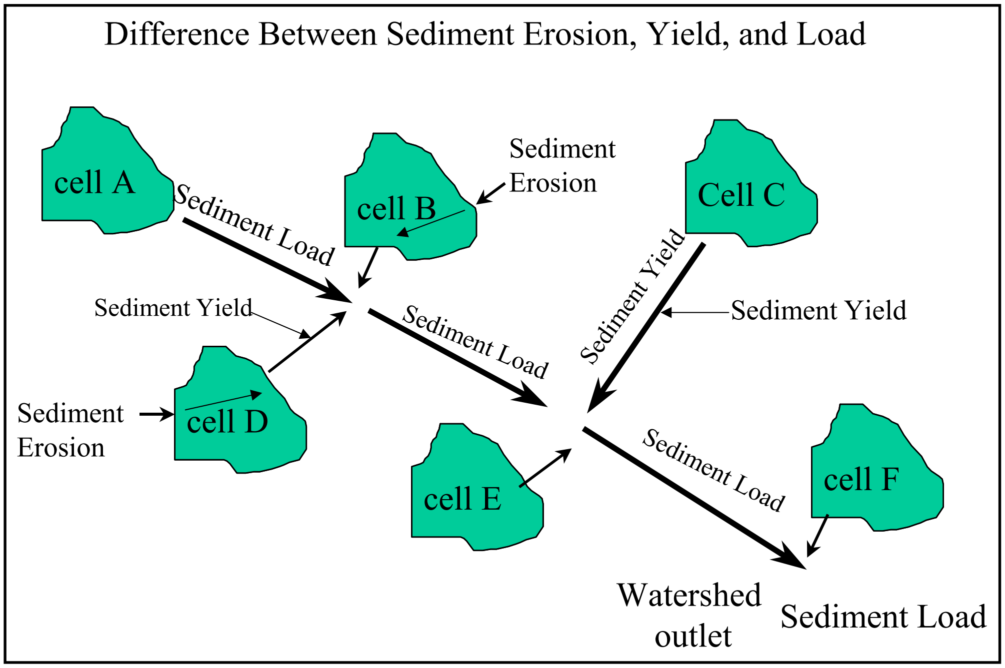


Figure 7.1 AnnAGNPS describes soil run-off in 3 basic categories: 1) Sediment Erosion is soils moving across the cells; 2) Sediment Yield is the soils of the cell depositing into the stream; 3) Sediment Load is the soil moving through the stream from reach to reach.

7.1 ANNAGNPS MODEL DESCRIPTION

LDEQ is utilizing a model called **Ann**ualize **A**griculture **N**on-**P**oint-**S**ource (AnnAGNPS), a Natural Resources Conservation Service (NRCS) sponsored model, to evaluate current sediment loadings in the watershed. The model is used to evaluate the effectiveness of various BMPs and compare them to standard agricultural practices. The model produces estimates of the amounts of sediment, phosphorus, nitrogen, and organics as the constituents travel overland, through the reaches and out the watershed outlet. It is an extremely robust model having over 900 input parameters. Cells (land area representations) of a watershed are used to provide landscape spatial variability. Each cell homogeneously represents the landscape within its respective land area boundary. The physical and chemical constituents are routed from their origin within the land area and are either deposited within the stream channel system or transported out of the watershed. Pollutant loadings can then be identified at their source and tracked as they move through the watershed system.

AnnAGNPS is a multi-temporal, continuous-simulation model that was set up to simulate 30 years of local climate data. The model produces sediment loss by particle size class and source of erosion and divides the runoff into 3 catagories: Sediment Erosion, Sediment Yield, and Sediment Load. Sediment Erosion is the amount of sediment that travels overland to the edge of the cell. Sediment Yield is the amount of sediment that is deposited into the stream network. Sediment Load is the amount of sediment that travels through the stream network and out the outlet. The results are rendered in standard tons/acre/year. Similarly, the model estimates runoff and loading of nitrogen, phosphorus, and organic carbon. The nutrient and organic results are rendered in lbs/acre/yr. In addition, the model predicts how much water runs off a watershed cell.

Type of Model Results	**Results**	**Units**	**Description**
Sediment Erosion	0.978	tns/ac/yr	Overland erosion
Sediment Yield	0.328	tns/ac/yr	Sediment deposited in streams
Sediment Load	0.1085	tns/ac/yr	Sediment that moves through stream reaches
Nitrogen Load	2.467	lbs/ac/yr	Nitrogen moving through reaches
Phosphorus Load	25.51	lbs/ac/yr	Phosphorus moving through reaches
Organic Carbon Load	8.749	lbs/ac/yr	Organic carbon moving through reaches
Water Load	10.533	inches/ac/yr	Amount of water running off cells into the stream reaches

Table 7.1 The AnnAGNPS modeling results above for subwatershed 030804 are "average annual" runoff of materials over a 30 yr simulation period.

7.2 ARCVIEW AND ANNAGNPS INTERFACE

The developers of AnnAGNPS have created a Geographic Information System (GIS)/ ArcView interface that helps extract, store, and organize input data as well as manipulate and display model outputs. The ArcView feature helps manipulate spatial and tabular data, extract spatial input parameters, develop analysis scenarios, and visualize input and output data in spatial, tabular, and graphical forms. It is a powerful graphical user interface and facilitates efficient and informed decision-making concerning agricultural nonpoint pollution control and watershed management. The results from the AnnAGNPS model run for the Little River watershed are displayed in illustrations on the following pages.

7.3 LANDUSE

Land use is the most significant factor in determining the amount of runoff coming from a cell. Agricultural practices that result in the exposure of bare soil to precipitation events clearly result in greater runoff amounts than land, where the surface soils have a healthy vegetative cover and root system to hold the soil in place. Forested and pasture areas generally have lower loading rates than agricultural fields with multiple annual tillage practices.

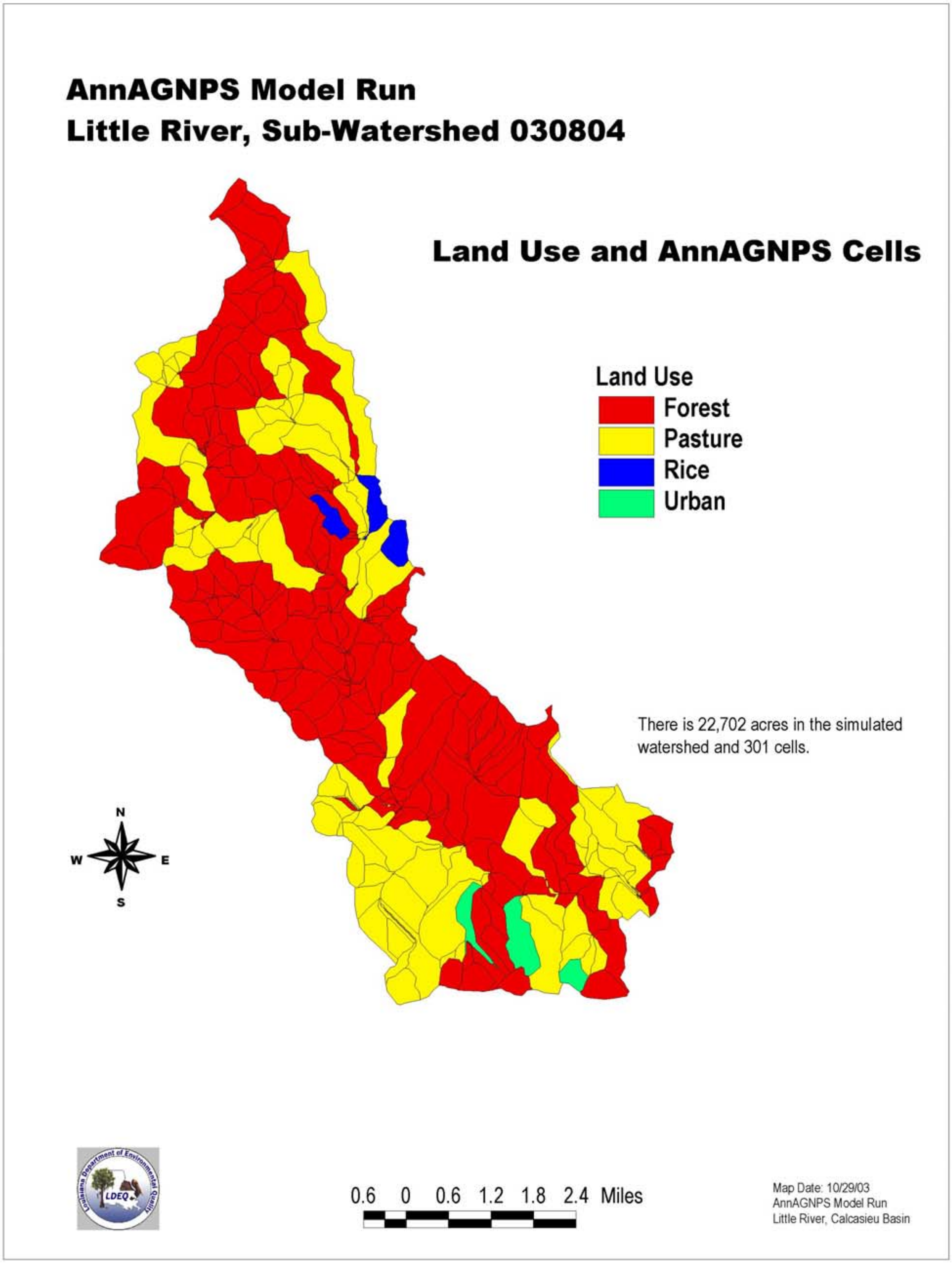


Figure 7.2 AnnAGNPS landuse.

7.4 LENGTH-STEEPNESS FACTOR (LS-FACTOR)

AnnAGNPS generates LS factors for each cell. They are physical factors that may explain why an area is losing soil and nutrients. LS factors are utilized as part of the RUSLE soil erosion equation and are basically the slope of the land. LS values are not absolute values, but represent the ratio of soil loss in a specific area to a value of 1.0 that is given to a slope with 9% steepness and is 72.6 ft long. The LS factors were generated by the model to determine areas that have the greatest potential for soil erosion. As you can see, the slopes are greatest near the bayou and tributaries. The model shows that riparian areas help prevent soil loss into the water ways. Forested riparian zones also provide shade over the waterways. DO is inversely proportional to temperature and the shade trees provide a canopy over the streams which keeps the water temperature lower and prevent DO from dissipating out of the water.

7.5 SOIL ERODIBILITY K-FACTOR

Soil Erodibility is a soil property that is defined as the ease with which soil is detached by a splash of rainfall or by surface flow or both. Physically, soil erodibility is the change in the soil per unit of applied external force or energy, namely rainfall or overland flow. Soil-erodibility factor (K) in RUSLE accounts for the influence of soil properties on soil loss during storm events. It is related to the integrated effect of rainfall, runoff, and infiltration on soil loss. Physical, chemical, and mineralogical soil properties, and their interactions, affect K values. Several erosion mechanisms are operating at the same time and it is unlikely that any one soil property will accurately describe K values for each soil.

7.6 SEDIMENT RUN-OFF

Sediment run off is principally related to landuse, slope (LS Factor), soil erodibility (K-Factor), and rainfall intensity. These variables are the most significant factors affecting agricultural NPS pollution. AnnAGNPS estimates three general types of soil erosion: sheet, rill, and gully. Sheet erosion is removed more or less uniformly from every part of the cell. Rill and gully erosion create small or large ravines by undermining and downward cutting of soils. Gully erosion is essentially larger and more pronounced rill erosion. Gullies eventually produce ditches or ravines exposing subsoils to erosion. AnnAGNPS estimates sheet, rill, and gully erosion for each cell. The results found on the following pages indicate where these activities are most likely to occur. Agricultural managers and farmers can use the maps to identify the critical areas in the watershed where BMPs should be installed. Also, certain landuses tend to produce more erosion than others.

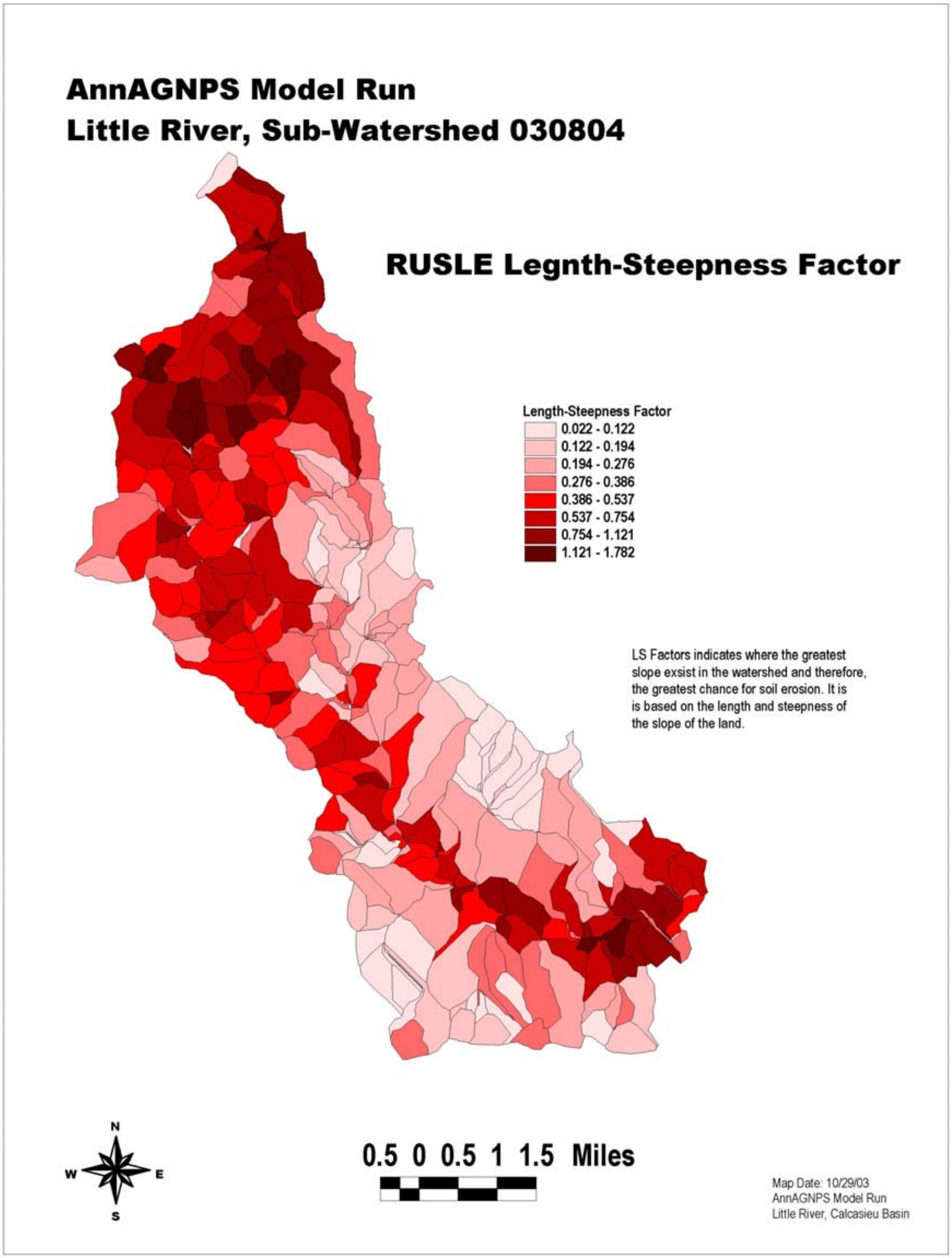


Figure 7.3 Length-Steepness Factors of Little River watershed.

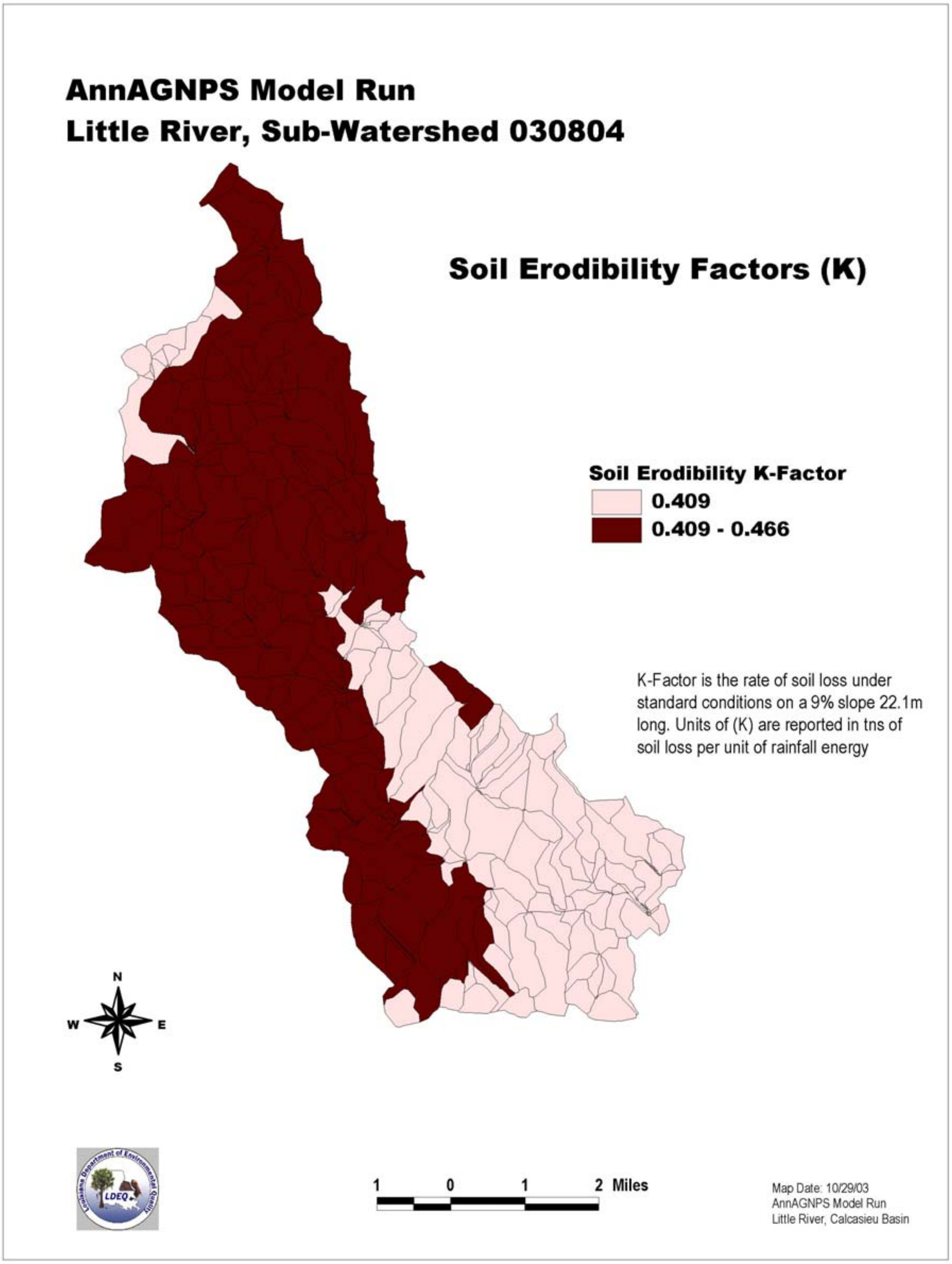


Figure 7.4 AnnAGNPS Soil Erodibility Factor.

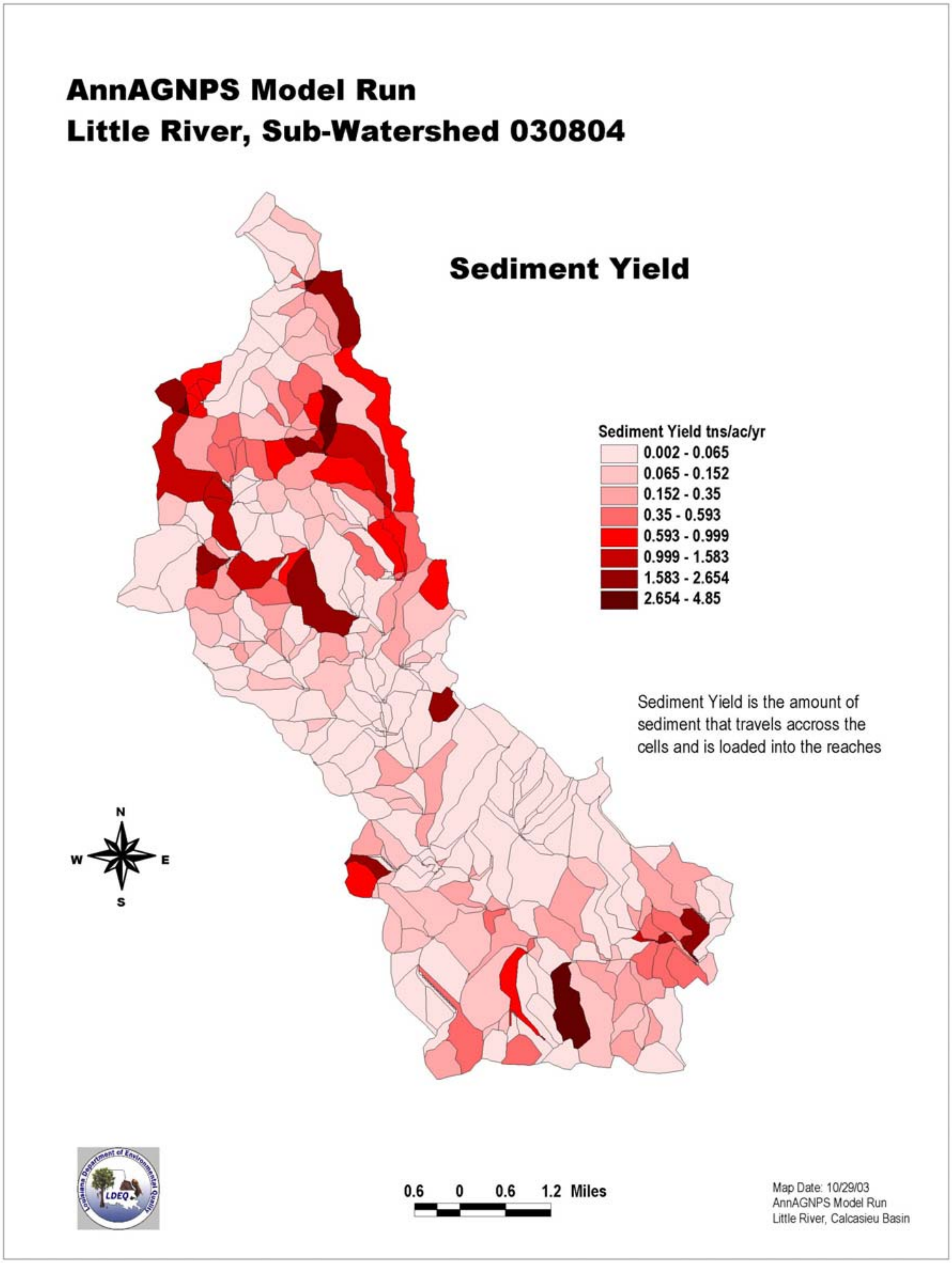


Figure 7.5 AnnAGNPS Soil Sediment Yield.

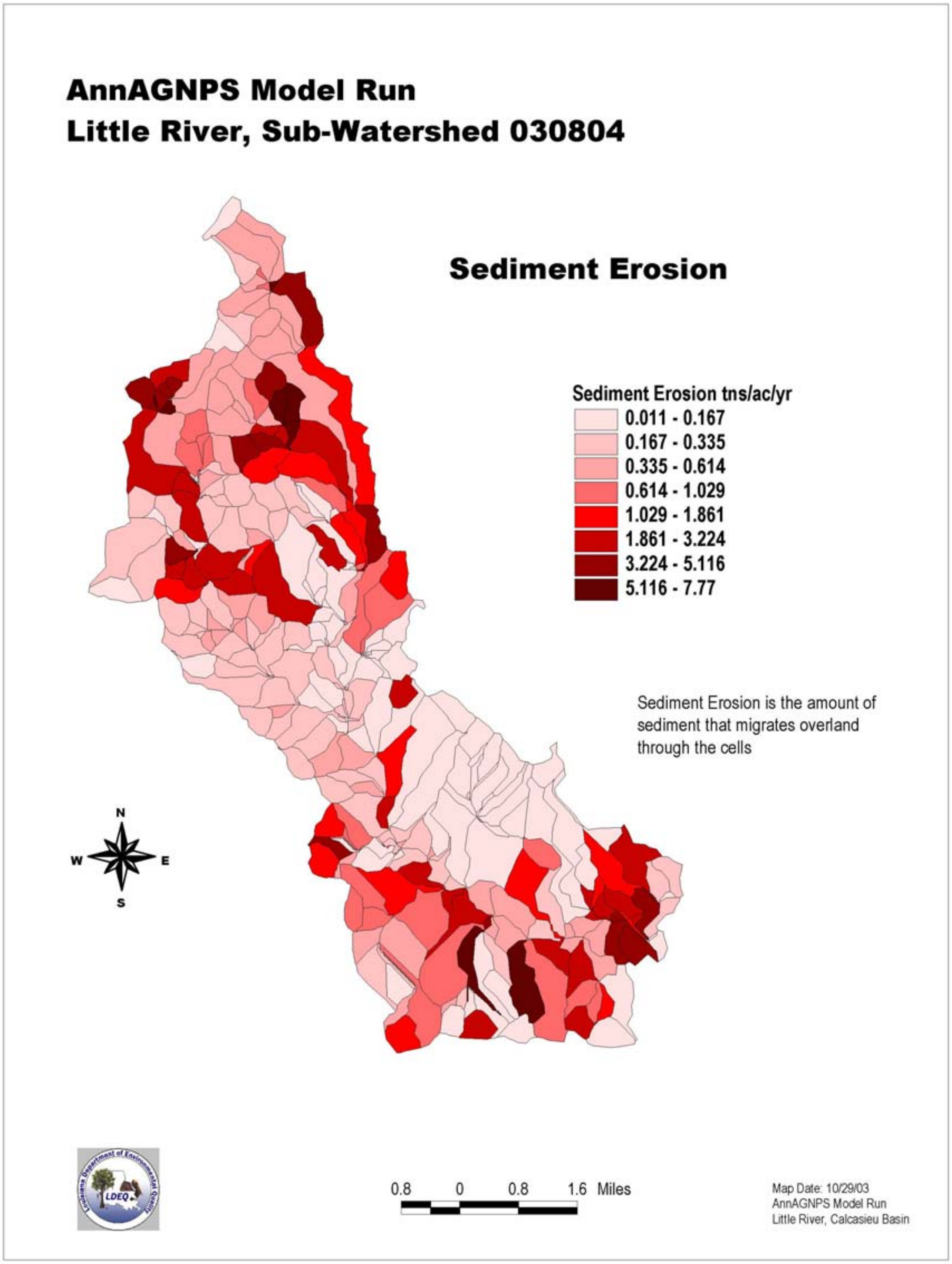


Figure 7.5 AnnAGNPS Sediment Erosion.

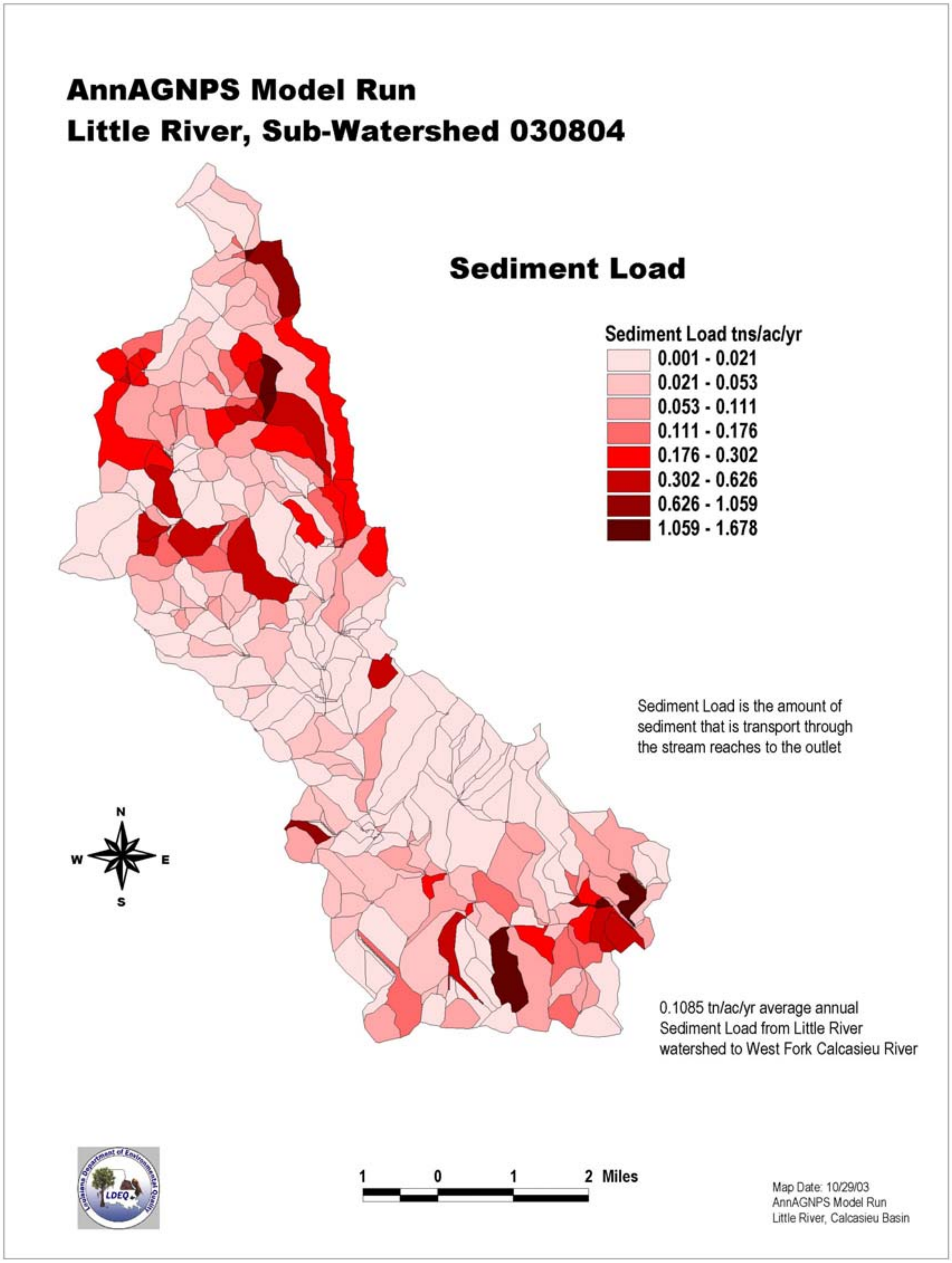


Figure 7.7 AnnAGNPs Sediment Load

7.7 Nutrients and Organic Carbon

Inputs of nitrogen and phosphorus are the primary causes of eutrophication in lakes. In general, runoff from watersheds under agricultural use has significantly higher nutrient concentrations than drainage waters from forested watersheds. Increased nutrient levels may result from fertilizer application and animal wastes. In a nationwide Environmental Protection Agency study, (Nonpoint Source - Stream Nutrient Level Relationships, 1977), it was determined that nutrient concentrations are generally proportional to the percentage of land in agricultural use and inversely proportional to the percentage of land in forested use.

The high levels of eutrophication in some Louisiana lakes and streams can be attributed to the nutrients derived from agricultural land, primarily nitrogen and phosphorus. Soluble nutrients may reach surface and ground water through runoff or percolation. Others may be adsorbed onto soil particles and reach surface waters with eroding soil. Nutrients are necessary to plant growth in a water body, but over-enrichment leads to excessive algae growth, an imbalance in natural nutrient cycles, changes in water quality and a decline in the number of desirable fish species. Factors influencing nutrient losses are precipitation, temperature, and soil type, kind of crop, nutrient mineralization, and denitrification. Chronic symptoms of over-enrichment include low dissolved oxygen, fish kills, murky water, and depletion of desirable flora and fauna. Excessive amounts of nutrients can also stimulate the activity of microbes, such as Pfisteria, which may be harmful to human health.

7.8 Nitrogen

Nitrogen can encourage nuisance phytoplankton growth in aqueous systems . Nitrogen chemistry is complicated by the multiple oxidation states the element assumes in its compounds. Those of greatest importance to agriculture runoff, however, are the -3, +3, and +5 oxidation states: ammonia (NH_3), nitrite ion (NO_2-), and nitrate ion (NO_3-). In aquatic systems excessive concentrations of nitrogen compounds can cause problems. The primary adverse effects are as follows: 1. Organic nitrogen compounds and ammonia are both oxidized in aquatic systems, with an accompanying loss of dissolved oxygen in the system. 2. In instances where nitrogen is limiting to growth in a particular aquatic ecosystem, discharge of nitrogen compounds can promote the growth of nuisance plankton. 3. The un-ionized ammonia (NH_3) species can be directly toxic to aquatic life. When ammonia enters the water, the hydrogen ions present immediately react and convert the species into an equilibrium mixture of two forms: the relatively nontoxic ammonium ion (NH_4^+) and the unionized NH_3, which is toxic.

Organic nitrogen contains small amounts of nitrogen incorporated into organic compounds, primarily unassimilated proteins. Bacterial action on such organic matter results in its degradation and the release of ammonia. The ammonia so produced may then be further oxidized to nitrite by bacteria such as *Nitrosomonas,* and the nitrite produced from this reaction can be oxidized to nitrate by other bacteria such as *Nitrobacter*. These biologically mediated reactions collectively referred to as *nitrification*. In areas subject to reasonably fast currents, the dilution of nitrogen occurs down current and oxidation of ammonia to nitrate prevents accumulation of soluble nitrogenous wastes in the water column.

7.9 PHOSPHORUS

Phosphorus can also contribute to the eutrophication of both freshwater and estuarine systems. While phosphorus typically plays the controlling role in freshwater systems, in some estuarine systems both nitrogen and phosphorus can limit plant growth. Algae consume dissolved inorganic phosphorus and convert it to the organic form. Phosphorus is rarely found in concentrations high enough to be toxic to higher organisms.

Although the phosphorus content of most soils in their natural condition is low, between 0.01 and 0.2 percent by weight, recent soil test results show that the phosphorus content of most cropped soils in the Northeast have climbed to the high or very high range (Sims, 1992). Manure and fertilizers increase the level of available phosphorus in the soil to promote plant growth, but many soils now contain higher phosphorus levels than plants need (Killorn, 1980; Novais and Kamprath, 1978). Phosphorus can be found in the soil in dissolved, colloidal, or particulate forms.

Runoff and erosion can carry some of the applied phosphorus to nearby water bodies. Dissolved inorganic phosphorus (orthophosphate phosphorus) is probably the only form directly available to algae. Particulate and organic phosphorus delivered to waterbodies may later be released and made available to algae when the bottom sediment of a stream becomes anaerobic, causing water quality problems.

7.10 ORGANIC CARBON

BOD in Louisiana waterways and sediments is largely composed of Carbonaceous BOD (CBOD). Animal waste and crop debris is the major organic pollutant which result from agricultural activities. These materials place an oxygen demand on receiving waters upon decomposition. If dissolved oxygen levels decrease to low levels and remain low, fish and other aquatic species will die. Often this occurs on a seasonal basis in Louisiana, during periods of low flow and warm water. Nonpoint source inputs can additionally stress a system under these conditions.

Disposal of animal wastes on land is a potential nonpoint source of water degradation. Runoff and percolation could transport organic matter and nutrients to surface and ground water. Animal wastes applied to land come from wastes removed from feeding facilities, runoff from feeding areas, and waste from animals on pasture and rangeland. Proper application of animal wastes provides nutrients for crop production and also reduces surface runoff. Appropriate animal and land management practices should be followed.

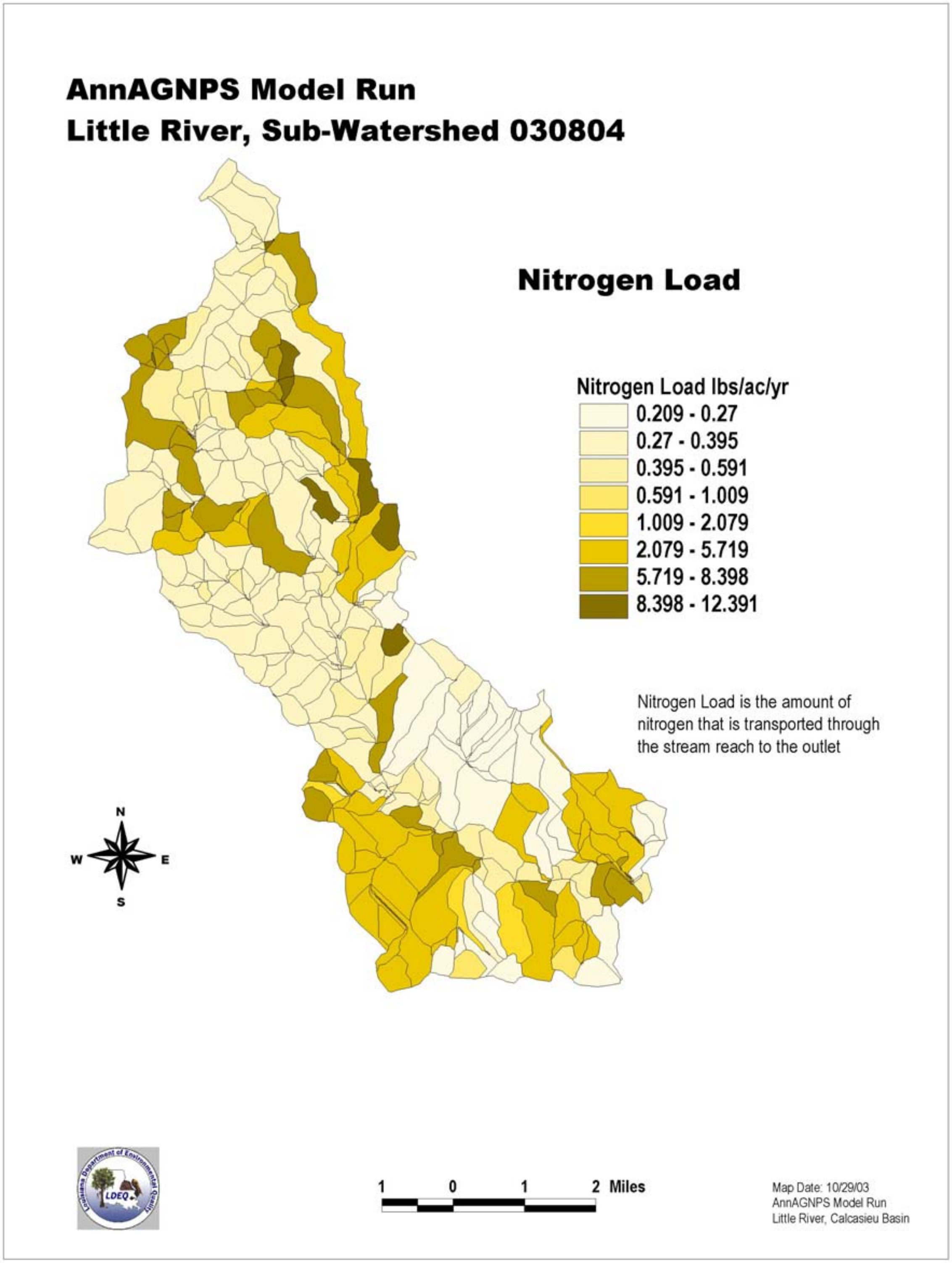


Figure 7.8 AnnAGNPS Nitrogen Load.

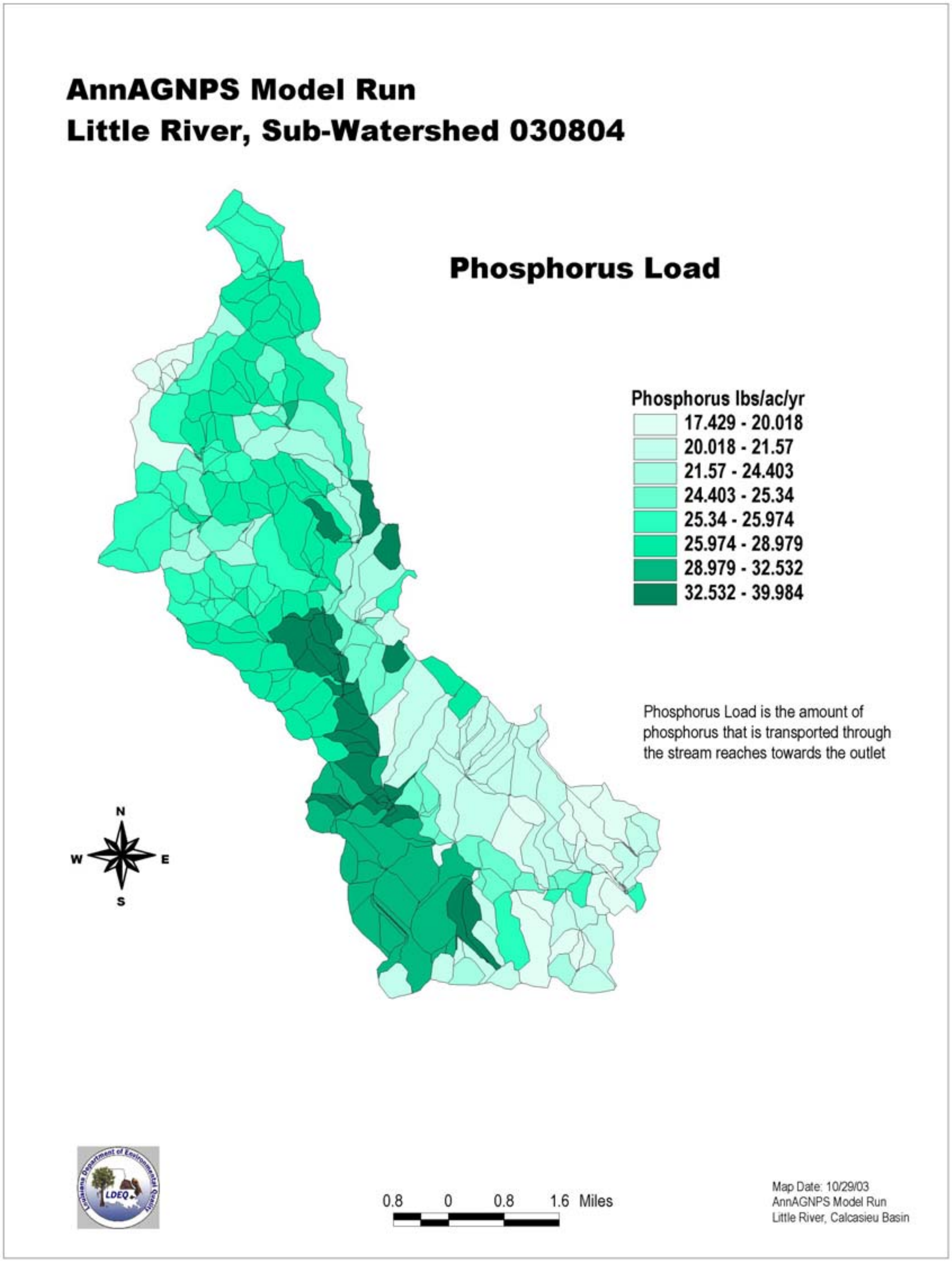


Figure 7.9 AnnAGNPS Phosphorus Load.

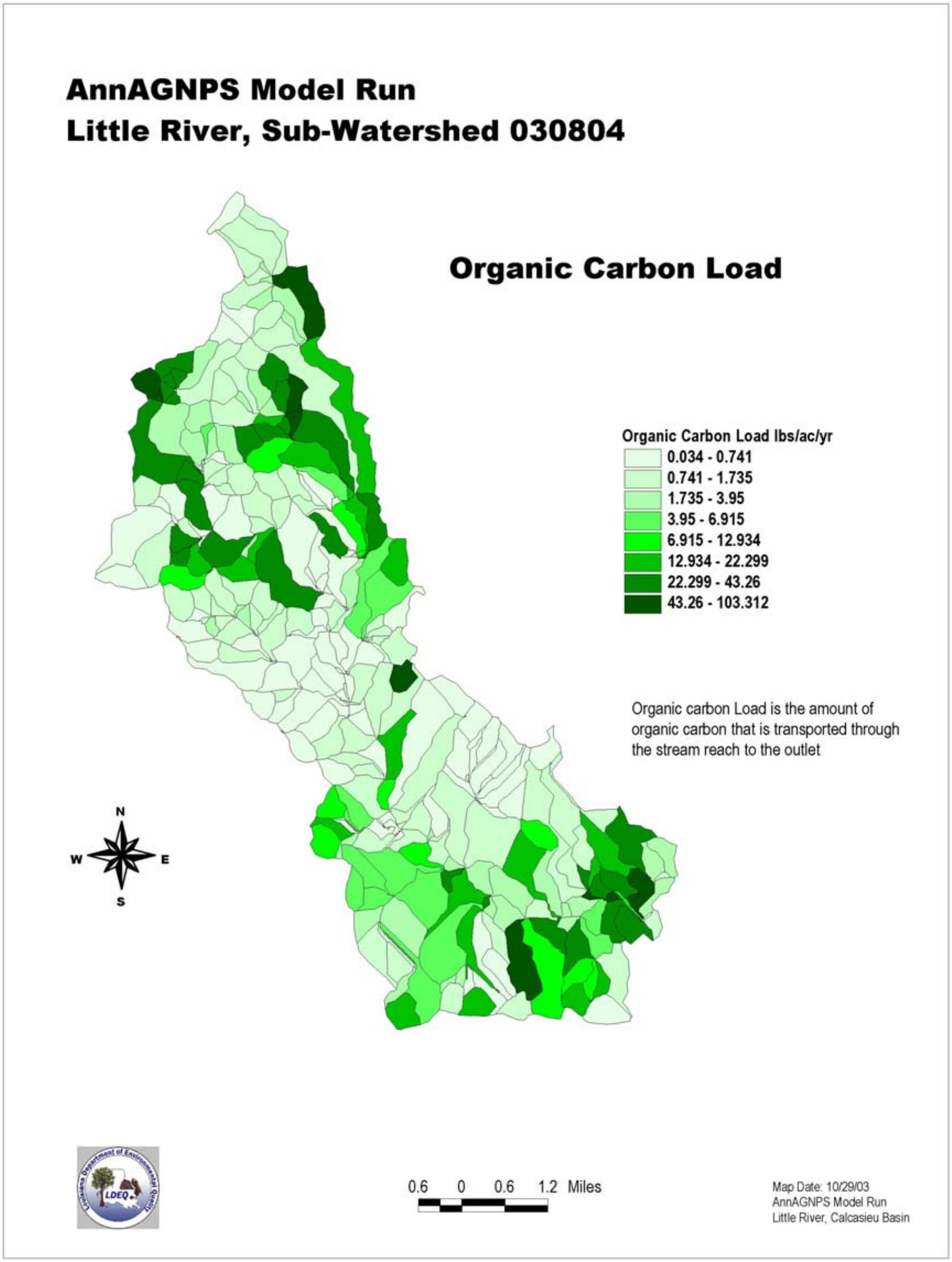


Figure 7.10 Organic Carbon Load.

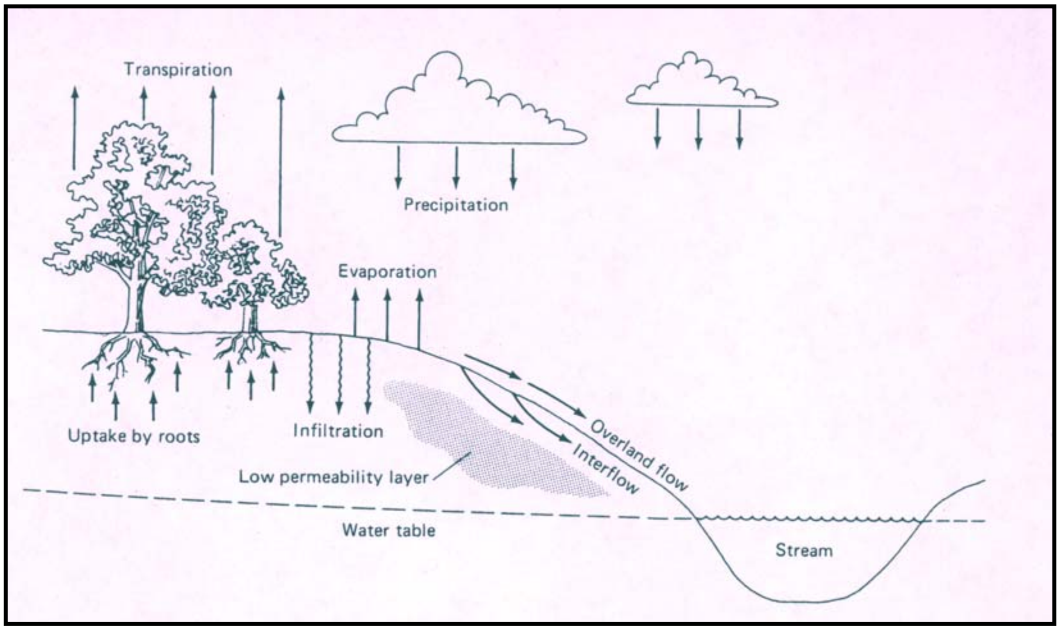


Figure 7.11 The figure above illustrates the hydrologic cycle. When rainfall falls on land, the water can follow several pathways. Some of the water will remain attached to vegetation and soil and soon evaporate after rainfall. Some of it is taken up by the roots of the plants and is evaporated through the leaves, a process called transpiration. Some of the rainfall will infiltrate into the soil where it migrates laterally toward a stream, a process called interflow. The water will also infiltrate into a permanent groundwater system. During heavy rainfall event, water will migrate overland to local waterbodies. Illustration and text provide by Drever, J.I. 1997.

7.11 Water Run-Off

The average annual rainfall in the Little River watershed is ~56 inches a year. AnnAGNPS estimates the average annual amount of water (in/acre/yr) running off of the cells. As you can see on the following illustration, water runoff varies considerably, ranging from 6.6 – 13.6 in/acre/yr. Water runoff is influenced by a number of factors including soil permeability, presence of impermeable surfaces, slope of the land, type of vegetative cover and root mass, climate, and the chemical properties of the soil. The average annual runoff for all cells is 10.53 inches/year. Approximately, 18% of the precipitation is running to the stream network and discharging through the system. This is normal for the type of soils in the area, which are composed of clays and silts. Sandy soils can absorb much higher rates of precipitation.

The model estimates that some cells are experiencing runoff amounts in excess of 13 inches/yr. The stream reaches in these areas may be experiencing bed and bank erosion along the stream network. In watersheds with large areas of impervious surfaces, upward of 50% of the sediment load can be attributed to stream erosion. In this case, water rushes overland and scours existing streambeds. Hydraulic modifications to bayous and rivers can also create an unstable system.

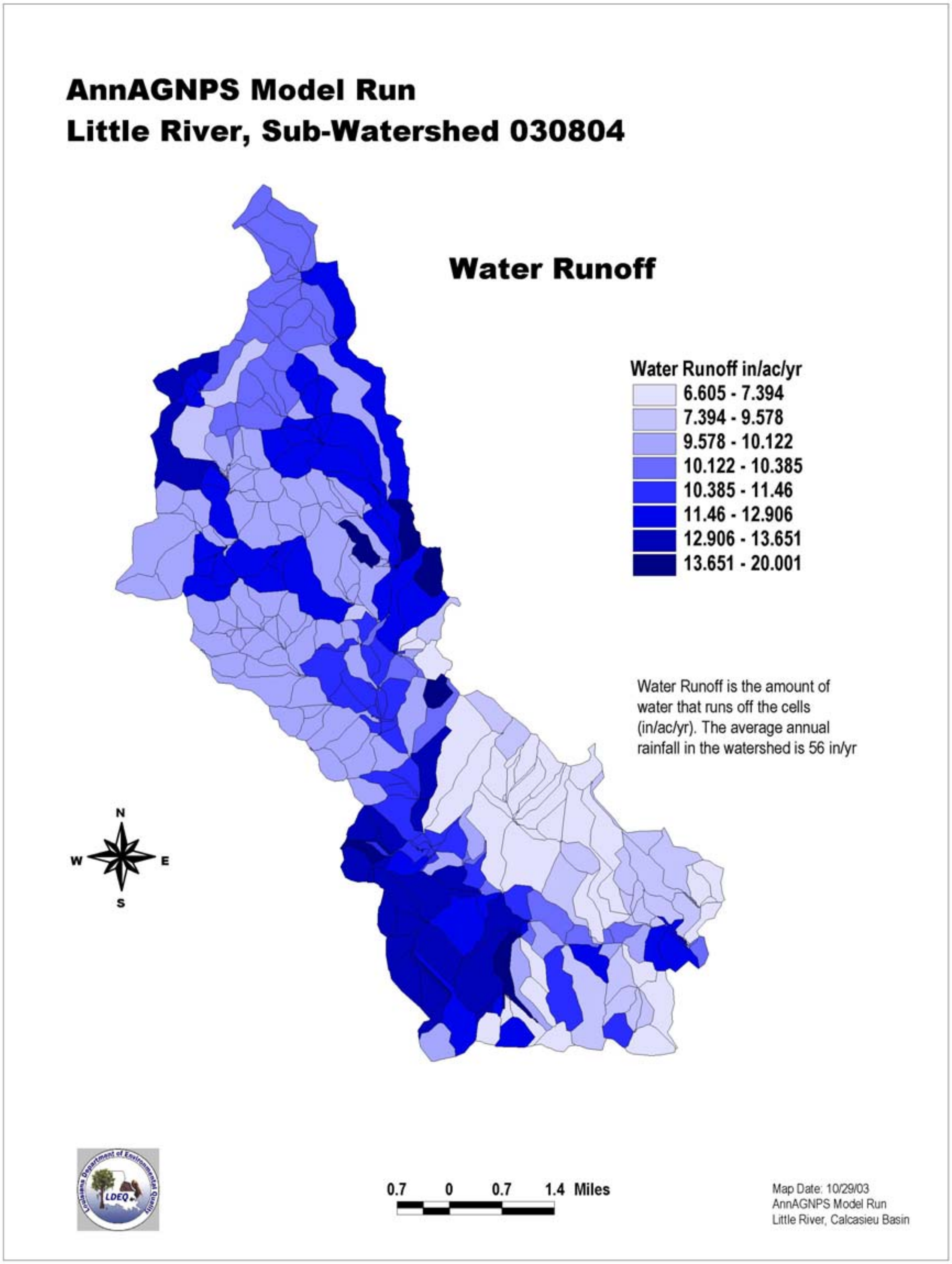


Figure 7.12 AnnAGNPS Water Runoff.

8.0 Best Management Practices Implementation Plan: Achieving goals in Watershed

8.1 Identifying High Priority Areas in the Watershed

The results from the AnnAGNPS modeling indicate that the majority of the NPS runoff is originating in the upper reaches of the watershed. The greatest slopes can be found in the northern section where the landscape contains small, gently rolling hills. There are also some elevated spots in the southeast section of the watershed north of the Little River just before its confluence with the West Fork of the Calcasieu River. BMP implementation should focus on these areas. The modeling results are a good indication of where the migrating sediments originate and they provide a good starting point for efforts to reduce NPS runoff from both silviculture operations and areas used to raise cattle.

The TMDL goal is to reduce NPS loading of oxygen demanding substances by 90%. It will be necessary to initiate an implementation plan, set measurable goals and milestones, and begin a monitoring program to sample any improvement in the watershed as the result of BMP implementation. Stake holder participation is a necessary component of any successful watershed implementation plan and the local community will be encouraged to get involved in the effort to reduce the NPS pollutant loads in the watershed. A schedule to meet goals outlined in the TMDL will be presented after this section and methods to monitor progress in the watershed and sources to finance BMP implementation will be discussed.

8.2 Achieving Forestry Goals in the Watershed

Mixed Long-Leaf Pine Forest makes up the majority of forested lands in the watershed followed by Bottomland Hardwood. Long-Leaf Pine grows in sandy and silty soil over hardpan clay, which is present throughout the watershed. These areas occur mostly in the higher elevations of the watershed extending up to the riparian areas along the tributaries and bayou. Because of the high sand and silt content, these soils tend to be highly erosive. Bottomland Hardwoods with mixed Cypress Tupelo are present in the lower elevations making up a natural riparian buffer area. A healthy riparian buffer is present along some of the tributaries and all along the Little River bayou in varied widths. Much of the bottomland hardwoods along the waterways remain, particularly in the southeastern portion of the watershed. Forestry BMPs should be implemented in the northern section of the watershed and a riparian zone should be maintained along the numerous little tributaries to Little River and Cypress Creek.

8.3 Forestry BMPS

Master Logger Program

The Louisiana Forestry Association (LFA) and the Louisiana Logging Council have created the Louisiana Master Logger Program. It is composed of an educational program, which outlines a number of Forestry BMPs, and distributes educational materials to foresters around the State. A Master Logger designation includes a five-step training curriculum that is designed for loggers, foresters, and landowners. The applicant must complete 30 hours of training to be certified. The designation also requires an additional 6 hours of continuing training annually to keep up on the latest forestry BMPs.

The main educational guide is called "Recommended Forestry Best Management Practices for Louisiana" by LFA, LDEQ, and Louisiana Department of Agriculture and Forestry. A copy of this document is appended to this document. LDEQ recommends that the landowners that are harvesting timber in the watershed participate in the Master Logger Program and request any loggers harvesting timber on their lands to follow BMPs recommend in the appended forestry manual.

Pasture farmers in the watershed can apply for the Forestry Productivity Program and receive up to $10,000 a year per landowner. The application is $25 and can be obtained from your Parish Farm Service Agency. Funds can be obtained for up to 50% of the expenses accrued a year to transform from agricultural fields to silviculture. A copy of the application is appended in this document.

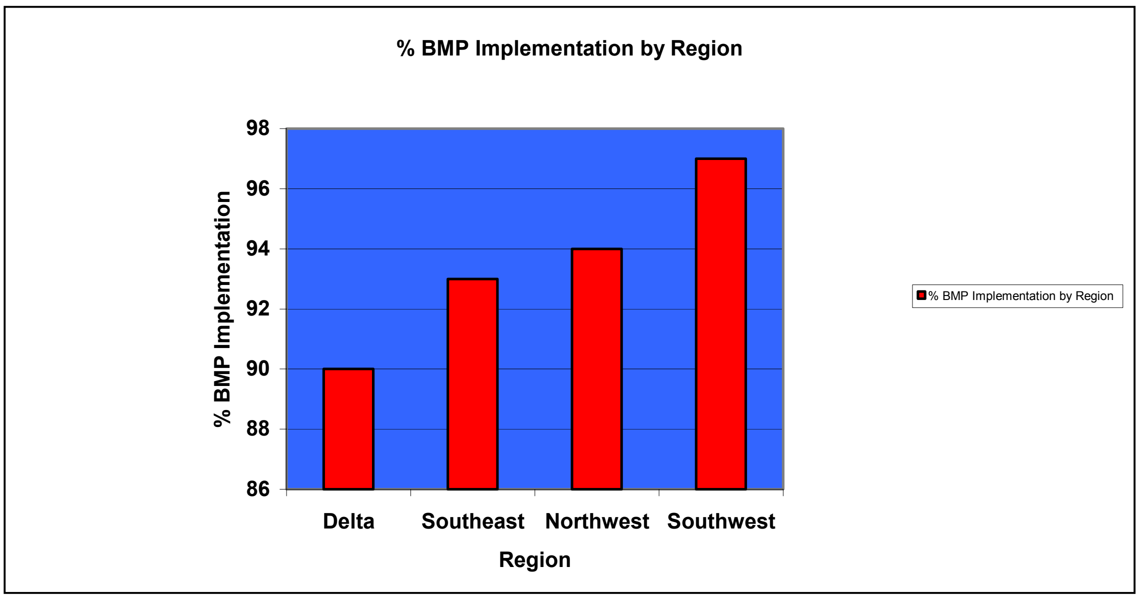


Figure 8.1 The bar graph above shows the rate of BMP implementation in the various regions in Louisiana. The Mill Creek watershed is in SW Louisiana where silviculture operators are implementing BMPs at a greater rate than the rest of the State.

Information was provided by the Louisiana Department of Agriculture and Forestry (LDAF) in 2001 to the LDEQ Nonpoint Source Program which detailed the amounts and types of BMPs already established in the Calcasieu Basin. The numbers reported that 249,389 acres of BMPs and 1,646 other BMPs have been established through the Environmental Quality Incentives Program (EQIP). Another 13,407 acres of BMPs have been established through Louisiana's Nonpoint Source Program (funded through USEPA §319(h) Program). Additionally, Conservation Operation programs have established BMPs on 85,954 acres and over 500,000 single BMPs in the Calcasieu Basin. These efforts can be thought of as a baseline of agricultural BMP implementation.

The rates of implementation of forestry BMPs have been tracked since 1985 by the Louisiana Office of Forestry. A 1985 survey showed a 10% compliance rate with recommended forestry BMPs, while a survey in late 2000 showed that 93% of logging sites chosen at random had BMPs in place.

8.4 ACHIEVING GOALS: BMP IMPLEMENTATION AND COST SHARE

Cost share funding for BMPs is a key element in a successful Implementation Plan. A number of Federal and State funding sources exist for BMP implementation, riparian zones, and land conservation. The LDEQ Non-Point Source group provides USEPA §319(h) funding to assist in implementation of BMPs to address water quality problems on reaches listed on the §303(d) list or which are located within Category I Watersheds as identified under the Unified Watershed Assessment of the Clean Water Action Plan. USEPA §319(h) funds were utilized to sponsor the cost sharing and monitoring projects discussed above. These monies are available to all private, for profit and nonprofit organizations that are authenticated legal entities, or governmental jurisdictions including: cities, counties, tribal entities, Federal agencies, or agencies of the State. Proposals are submitted by applicants through a Request for Proposal (RFP) process and require a non-federal match of 40% of the total project cost consisting of funds and/or in-kind services. Further information on funding from the Clean Water Act §319 (h) can be found at the LDEQ web site at: www.deq.state.la.us.

8.5 OTHER FEDERAL AND STATE FUNDS

The U.S. Department of Agriculture (USDA) offers landowners financial, technical, and educational assistance to implement conservation practices on privately owned land to reduce soil erosion, improve water quality, and enhance crop land, forest land, wetlands, grazing lands and wildlife habitat. One of these programs is the Conservation Reserve Program (CRP). It is designed to encourage farmers to convert highly erosive cropland to vegetative cover, such as native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Farmers receive annual rental payment for the term of the multi-year contract. The Conservation Reserve Enhancement Program (CREP) combines the resources of the CRP program with that of the State government. This program focuses on NPS pollution and water and habitat restoration. The Environmental Quality Incentives Program (EQUIP) is another source of funding available to the farmers for conservation practices. These are a few of the State and Federal funding sources available to agricultural landowners that will help with the cost of reducing NPS run-off from their fields.

8.6 TMDL MONITORING SCHEDULE

As LDEQ continues to monitor the water bodies across the state on the 4-year basin cyclic program, annual progress made in BMP implementation will be documented and reported to EPA, the NPS Interagency Committee and the general public through LDEQ's website. The first cycle of water quality monitoring will utilize the data collected to develop the TMDL and devise the watershed restoration action strategy. The second cycle will provide a baseline data for TMDL Implementation Plan and third cycle will determine whether the Implementation Plan has been effective in reducing nonpoint source pollutants and improving water quality within the water body. If this third cycle of water quality monitoring does not indicate a significant improvement, then LDEQ and the cooperating federal and state agencies will determine whether back-up authorities are necessary to achieve the BMP implementation required to reduce nonpoint sources of pollution and improve water quality.

8.7 Future Objectives and Milestones:

The objective is to get as many of the landowners in the Little River watershed to implement BMPs as possible and to restore the designated uses back to the bayou in 10-15 years. As outlined in the TMDL, it will require a 90% reduction in NPS pollution. Restoration will require the implementation of BMPs and will require the joint efforts of foresters, agriculture producers, landowners, government, private citizens and private organizations working together. The Louisiana Cooperative Extension Service (LCES) and Louisiana State University (LSU) AgCenter conducted a commodity-specific BMP review. These reviews were conducted through a multi-agency/organization partnership made up of research and extension scientists, the Louisiana Farm Bureau (LFBF), the Natural Resources Conservation Service (NRCS), the LDEQ, USDA-Agriculture Research Service (ARS), and agriculture producers.

9.0 Rural Residential Best Management Practices

9.1 Introduction

The types of pollutants associated with the low dissolved oxygen concentration were sediments, nutrients, and organic enrichment. These pollutants come from sewage systems, lawns, and pets. Oil and grease and metals also continue to be included in the array of pollutants associated with Rural Residential nonpoint source pollution. Oil and grease come from streets and driveways and can also from people who change the oil in the family automobile and dispose of the used oil in the local ditch. In order to address the long-term water quality goals of restoring the designated uses for Rural Residential stream, the types of pollutants defined will need to be reduced.

9.2 BMPs to Reduce Rural Residential NPS Runoff

Citizens and city planners have a wide variety of Rural Residential BMPs to choose from to address the many different sources of NPS pollution in Rural Residential settings. A list of Stormwater BMPs are available that are LDEQ approved methods for construction sites, parking lots and other impervious surfaces, industrial parks, residential homes and lawns, and automobile service centers. Currently, there are no educational programs or any systematic reduction program for Rural Residential NPS pollution in place in the Little River watershed.

9.3 RURAL RESIDENTIAL EDUCATIONAL MATERIALS

Educational materials such as brochures, fact cards and pamphlets are an important component to any watershed or statewide educational program. People need to clearly understand what the water quality issue is and how their activities contribute to the pollution problem. The educational materials that LDEQ has designed have been very popular with both adults and children and have been widely distributed through many workshops, schools, conferences, and other public events across the state. The messages are simple, but clearly stated so that each individual can understand which type of actions he can take to reduce nonpoint source pollution from his home, lawn, or neighborhood. Examples of the message on some of these materials have been included here and copies can be obtained by contacting the Louisiana Department of Environmental Quality (LDEQ).

9.4 FUTURE OBJECTIVES AND MILESTONES

The future objectives and milestones for the Rural Residential nonpoint source program are to continue to educate city officials, engineers, planners, developers, and the general public about Rural Residential nonpoint source pollution. This educational program will rely on materials and information already developed, but will continue to build on new information that has been successfully utilized in other states and cities. Information on home lawn chemicals, Rural Residential forestry, sustainable and cluster development, Rural Residential wetland detention areas, and many other technologies will continue to be provided to the cities across the state. In addition to providing educational materials, LDEQ will work with other state and local governments to form local nonpoint source working groups or coalitions where the specific nonpoint source problems can be identified and best management practices (BMPs) implemented to reduce and control them.

9.5 ACHIEVING GOALS

Addressing Rural Residential nonpoint source pollution is difficult since there is not a federal or state infrastructure for Rural Residential areas like there is for agricultural and forested areas of the state. However, there are many things that can be done to address Rural Residential nonpoint pollution issues. These activities include: storm drain stenciling and marking programs that can be disseminated into the local community; Rural Residential nonpoint source educational materials that can be distributed through parish and city offices; an Rural Residential educational video that highlights the pollution problems and pollution control methods that can be implemented to reduce these pollutants; an Rural Residential educational program developed and implemented through statewide organizations such as the Louisiana Cooperative Extension Service, the Office of Soil and Water Conservation, Louisiana Department of Natural Resources/Coastal Management Division, Natural Resources Conservation Service, Resource Conservation and Development Districts, Rural Residential Forestry Council, Municipal Associations, etc. develop and/or implement local ordinances that require implementation of Rural Residential best management practices; and encourage and track the use of checklists such as Pesticide Application Checklist, Auto Repair Checklist, and the Construction Site checklist as a method to track BMP implementation.

9.6 RURAL RESIDENTIAL PROGRAM TRACKING AND EVALUATION

In order for progress to be monitored and evaluated, it is important to track the level and also the pace of implementation of the goals and objectives outlined within this document. LDEQ reports on progress made in all of the areas of the NPS Management Program to the NPS Interagency Committee. This is done through quarterly newsletters and meetings and also through LDEQ's web-site. Progress is reported on all of the goals and milestones outlined within the NPS Management Plan to EPA Region 6 on an annual basis. Semi-annual reports highlight project activities and progress made in specific areas of the program.

10.0 HOME SEWERAGE BEST MANAGEMENT PRACTICES

Figure 9.1 Most of the Rural Residential homes in the watershed utilize septic systems to treat their sewage.

10.1 INTRODUCTION

Ground and surface water pollution are major considerations when on-site sewerage treatment systems are used. Sewerage treatment and disposal systems should be designed and operated in a manner, which prevents the degradation of ground and surface water quality. Septic tank systems used in undersized lots or where soils are unsuitable for proper treatment of wastewater are subject to undesirable conditions such as widespread saturation of the soil and malfunction of the treatment system. Malfunctioning systems result in sewerage leaching into ground water and into roadside ditches, contaminating surface water.

Septic tank systems must be designed so that they are compatible with the geological attributes of the area. If the ground water level is high (less than 4 feet below the surface) or if the soil is extremely permeable, the soil will not be effective in removing pollutants and the ground water may become contaminated, resulting in a public health hazard. Many diseases, including infectious hepatitis, typhoid fever, dysentery, and some forms of diarrhea are caused by water and food contaminated with sewerage and can easily be spread by flies.

One of the main problems with using conventional septic tank soil absorption systems in Louisiana is that 87 percent of the soil associations in Louisiana are considered inadequate for conventional septic tank systems as determined from the Soil Limitation Ratings for Sanitary Facilities (LDOTD, 1981). Another major component to the pollution caused by septic tank systems is inadequate enforcement of the State Sanitary Code. The State of Louisiana currently has regulations concerning private sewerage disposal systems under the State Sanitary Code (LHHRA, 1974) and the Department of Health and Hospitals (DHH) (LR, 1980). A majority of the sanitarians expressed concern that there is control over new septic tank systems being installed, but there are extensive problems with monitoring the maintenance of existing systems.

10.2 Achieving Goals: Educational Programs

There are several issues or program activities that need to be addressed to reduce the water quality problems that are associated with home sewerage systems. One of the most important steps is continued education of the homeowner about how his/her home sewerage system works. Most homeowners have no idea how to maintain their home sewerage system for maximum efficiency. A second aspect of the statewide program that needs to be addressed is the lack of inspection of home sewerage systems. The local parish sanitarian office typically does not have sufficient staff to inspect all of the systems across the parish. Even if the system was inspected, it is often difficult to force an action to correct the problem. LDEQ and LDHH are working together to ensure that more education about the problems that these systems cause to water quality across the state will result in more stringent regulations on maintenance of new and existing home sewerage systems. LDEQ is developing a general permit for individual sewage disposal systems that will apply to all such systems that discharge water. This permit may be issued by the end of 2004.

LDEQ has worked with the Louisiana Department of Health and Hospitals on statewide educational programs aimed at reducing fecal coliform bacteria and nutrients from home sewerage systems. An educational brochure and video were produced that focused on the various types of home sewerage systems that are approved for use in Louisiana. Each type of system was explained along with maintenance requirements recommended to keep the system functioning properly. A maintenance checklist was also included so that the homeowner could keep a record of the steps that had been taken to clean the system out or to have it repaired.

The educational video has been reproduced and distributed across the state in parish offices of the Department of Health and Hospitals and the Louisiana Cooperative Extension Service. These materials are important components for the statewide educational program on home sewerage systems.

The primary goals of the Home Sewerage Statewide Educational Program are to continue to work with the Department of Health and Hospitals and parish governments on more effective inspection programs to ensure that the regulations, which require home sewerage systems to function properly are enforced. Implementation of the short term and long term objectives described above should result in an increased level of compliance across the state and a > 50% reduction of fecal coliform problems from home sewerage systems during the next 10-15 years.

10.3 HOME SEWERAGE SYSTEMS APPROVED FOR USE IN LOUISIANA

Septic Systems

A septic tank is a watertight tank constructed of steel, concrete or other approved materials in which the suspended solids of sewerage settle out and are largely changed into liquids or gases by microbial degradation. The remaining residue in the tank is a black semi-liquid sludge that must be removed periodically from the tank. Although relatively few disease organisms should be present in the sludge material, precautions should be taken in cleaning the tank and the sludge material safely disposed. Cleaning and disposal of sludge material from septic tanks can be provided by commercial services. These services are controlled by a permit system, required by local parish health units in accordance with Chapter 13 of the State Sanitary Code.

A series of single compartment septic tank systems or a multiple compartment septic tank system has proven to be more effective than the individual septic tank system, but the individual septic tank system is still acceptable. Information on the velocities of flow through the system and the types of tees and baffles required for the inlet and outlet valves are included within the description of septic tank systems. Estimates of capacities and size for a system are also included, with recommendations for the types of materials that should be utilized in their construction. Recommendations are also made for inspection and cleaning of the systems with the optimum time period being every two to five years, although the average period between cleaning was estimated to be between eight and ten years.

Septic Tank Effluent

Although many people believe that discharge waters from a septic tank system are clean and pure; this is not the case. The effluent of the liquid discharged from a septic tank system is classified as primary treatment, usually being foul and potentially dangerous, often containing disease-causing bacteria. Therefore, discharges of septic tank effluent are not allowed in street gutters, surface ditches, or streams, according to regulations in the Louisiana State Sanitary Code. The method recommended for treatment of septic tank effluent is a soil absorption trench system. If the absorption trench is not possible due to poor soil or drainage conditions, then a small oxidation pond or a sand filter bed can also be utilized for secondary treatment of septic tank effluent.

10.4 PROGRAM TRACKING AND EVALUATION

Tracking installation and maintenance of home sewerage systems is a labor intensive job that requires sufficient staff to conduct inspections. The Nonpoint Source Unit will work with the Parish Sanitarian Office in watersheds across the state where home sewerage systems have been identified as contributing to use impairment. Through this partnership, LDEQ could provide federal funds to expand their present staff capabilities for home sewerage system inspection for a three-year period. DHH staff would inspect existing home sewerage systems to determine if they function properly and work with the homeowner to correct any problems that are identified. These staff would also assist in establishing a parish-wide database to record the inspections and track progress in correcting problems that have been identified through the inspections. LDEQ will report on the results of this project through semi-annual and annual reports that are submitted to EPA.

- Implement the home sewer inspection and tracking program (short-term);
- Work with the Parish Health Sanitarian Office to determine the extensiveness of the inspections and a timeline to complete them (short-term);
- Assist the parish office in establishing a computer tracking system that identifies where inspections have been made, problems identified, actions taken and timeline to correct the problems (short-term);
- Utilize federal funds to support this pilot project through additional staff for conducting the inspections, establishing the computer tracking system and working with the homeowner on correcting the problems that were identified through the inspection process (short-term);
- Link results of parish-wide sewer inspection and tracking program with in-stream water quality improvements (short and long-term);
- Report results of the pilot project to EPA on a semi-annual and annual basis (short-term);
- Submit a final report that summarizes the results of the project to EPA (short-term);
- Determine if the project was successful and transfer to other priority watersheds if it proves to be an effective mechanism to reduce the fecal coliform problems associated with home sewerage systems (long-term);
- Work with LDHH to determine if this program can become established as a statewide program that is supported through a combination of federal and state funds (long-term).

11.0 PASTURELAND GRAZING

Figure 11.1 Approximately 42% of the land area in the Little River watershed is used for pastureland grazing. Stocking densities in the area about 1 head of cattle per acre of land.

11.1 INTRODUCTION

Grazing cattle on pastureland is a common practice in the Little River watershed. Livestock often seek the shade offered in the riparian zone around streams and use the stream itself as a water source. When livestock are not fenced out of riparian zones, water quality has the potential to decrease.

When allowed inside the riparian zone, livestock can directly degrade water quality in multiple ways. Fecal matter can be deposited into the water adding nutrients and bacteria directly to the stream. The undigested organic material associated with fecal matter also has the potential to decrease DO as bacteria degrade it. Furthermore, the trampling by hooves can collapse stream banks and increase turbidity by churning up the streambed.

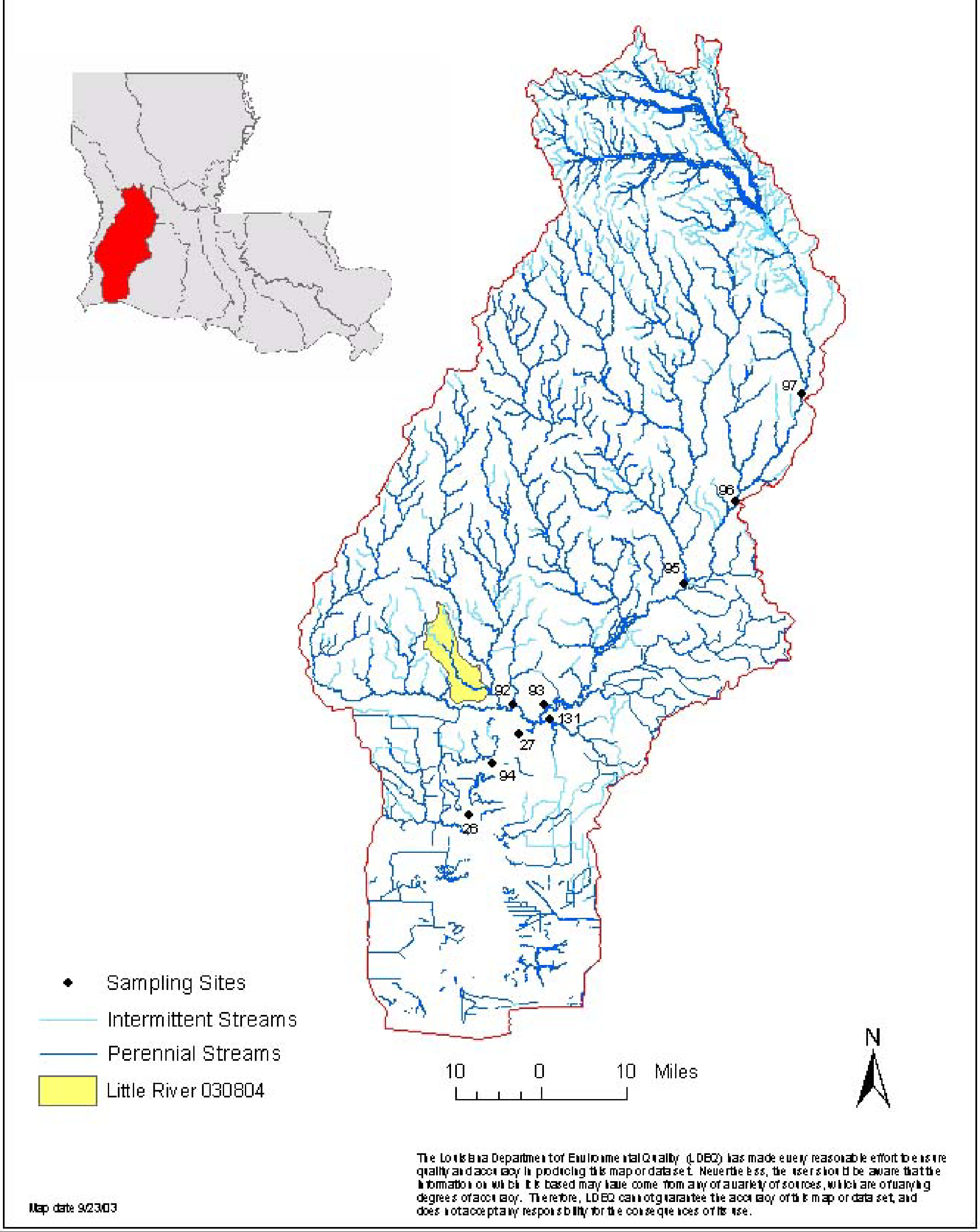
ACHIEVING GOALS IN THE WATERSHED: PASTURELAND GRAZING

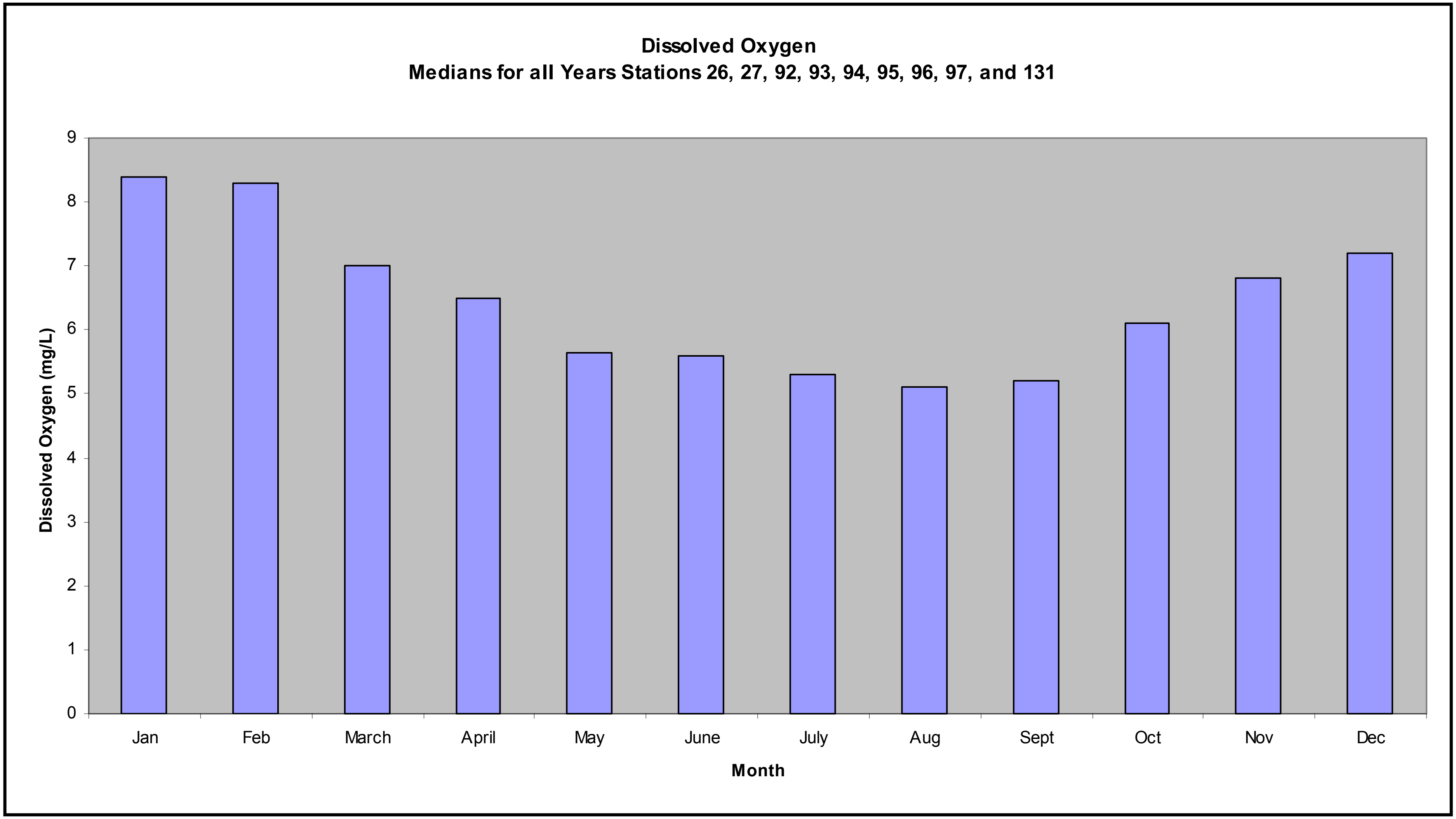
Livestock allowed in riparian zones also have the potential to indirectly degrade water quality if not managed properly. Groundcover within the riparian zone can be decreased as a result of overgrazing and from being trampled by hooves. The loss of groundcover results in unstable banks that can be easily eroded and fill streambeds in with sediment. It also decreases the filtering capabilities of the riparian zone. Maintaining quality riparian zones in pasturelands is especially important for filtering fertilizers and pesticides that are applied to pastures out of runoff.

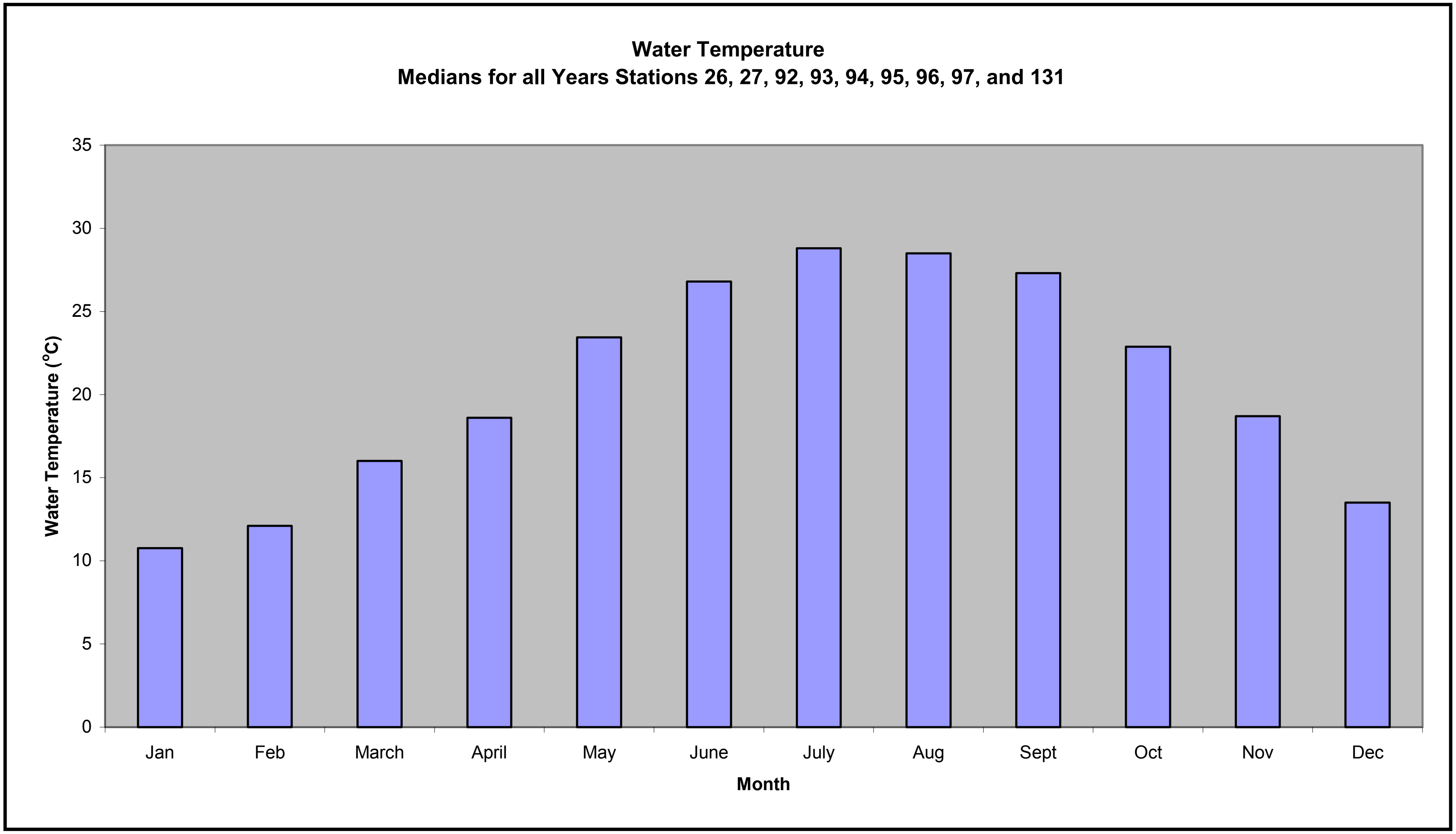
A number of cattle are already allowed in and on the banks of the Little River and appear to be destroying the banks and decreasing water quality. Convincing producers to reduce livestock access to the bayou and riparian zones should help improve water quality. Furthermore, as the current trend in South Louisiana is to convert cropland to pastureland, it is important for producers to be aware of the water quality issues associated with livestock production and install BMPs before cattle are stocked. These measures should help prevent further degradation of water quality in Little River Watershed.

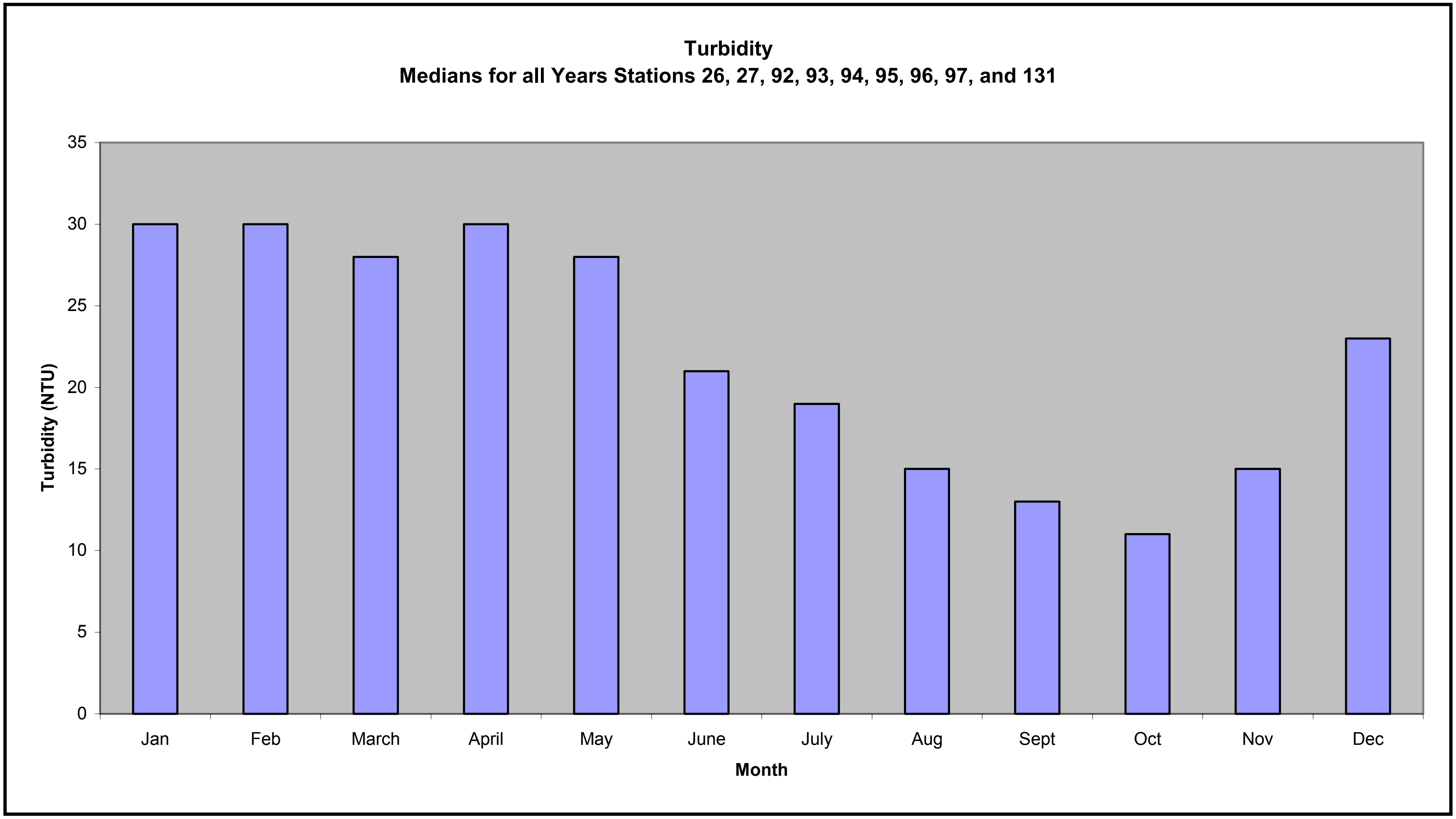
APPENDIX A

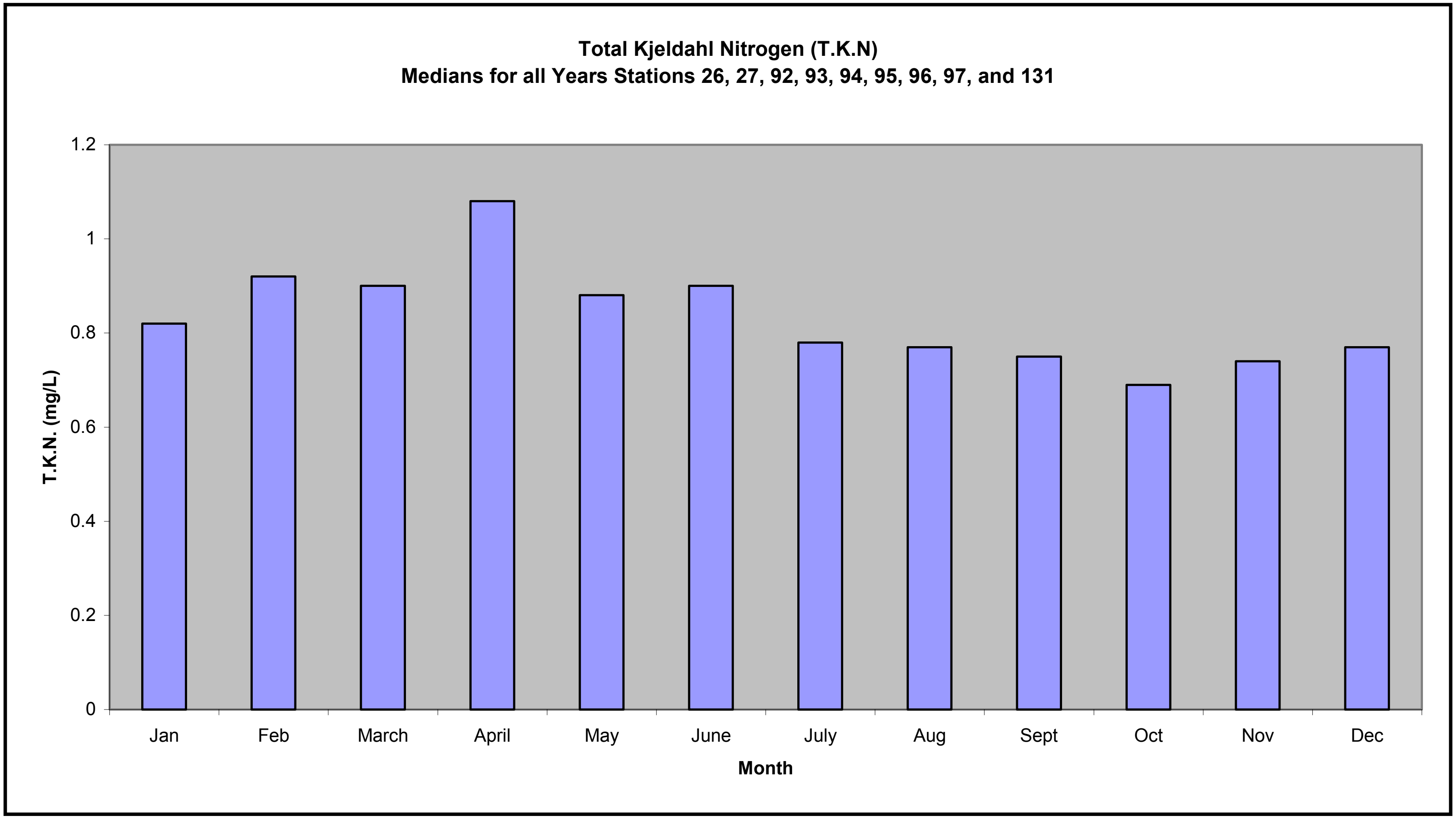
Long Term Water Sampling Sites in the Calcasieu Basin

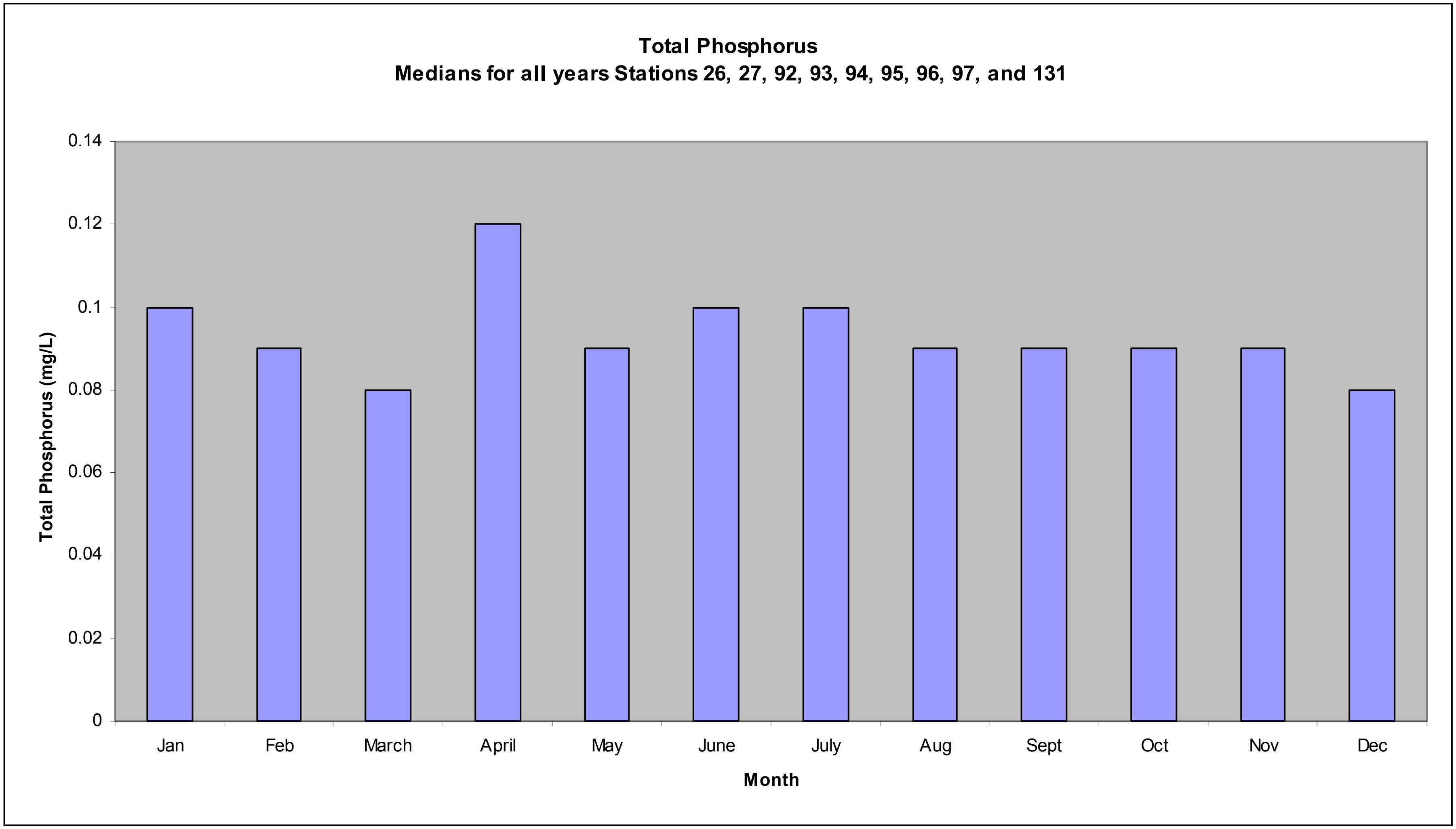


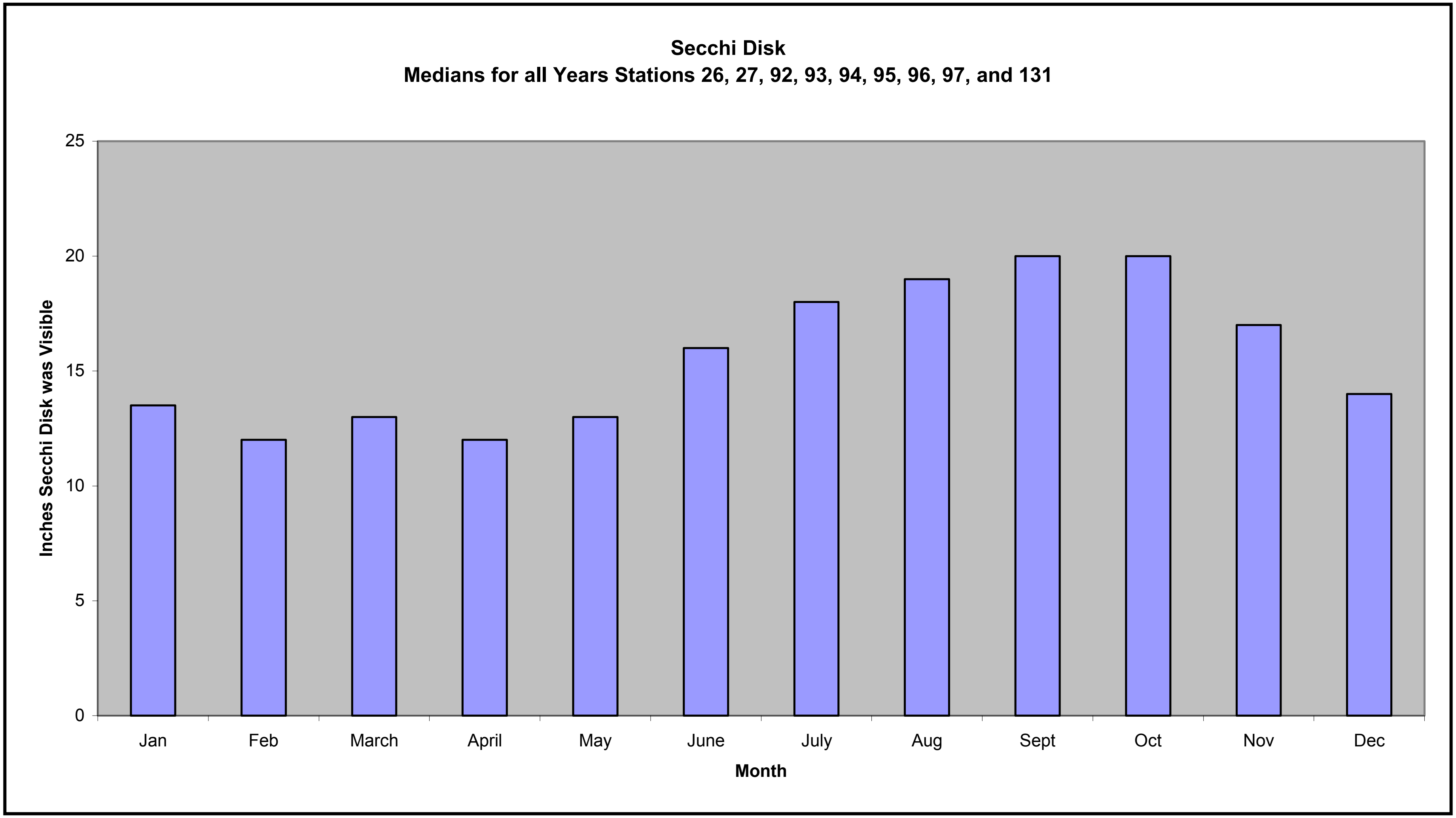

Dissolved Oxygen
Medians for all Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
Dissolved Oxygen (mg/L)
0
1
2
3
4
5
6
7
8
9
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

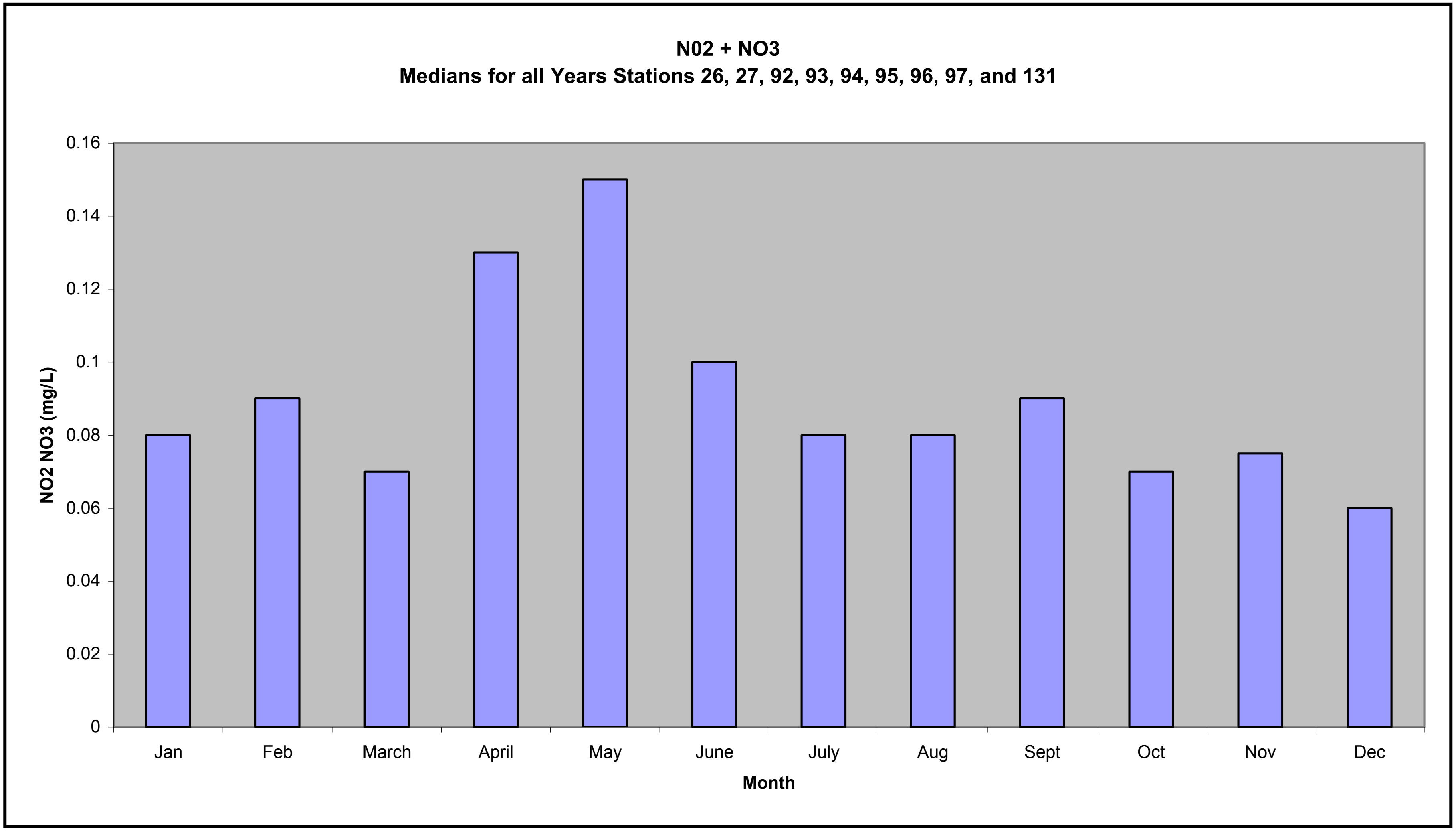

Water Temperature
Medians for all Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
Water Temperature (°C)
35
30
25
20
15
10
5
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

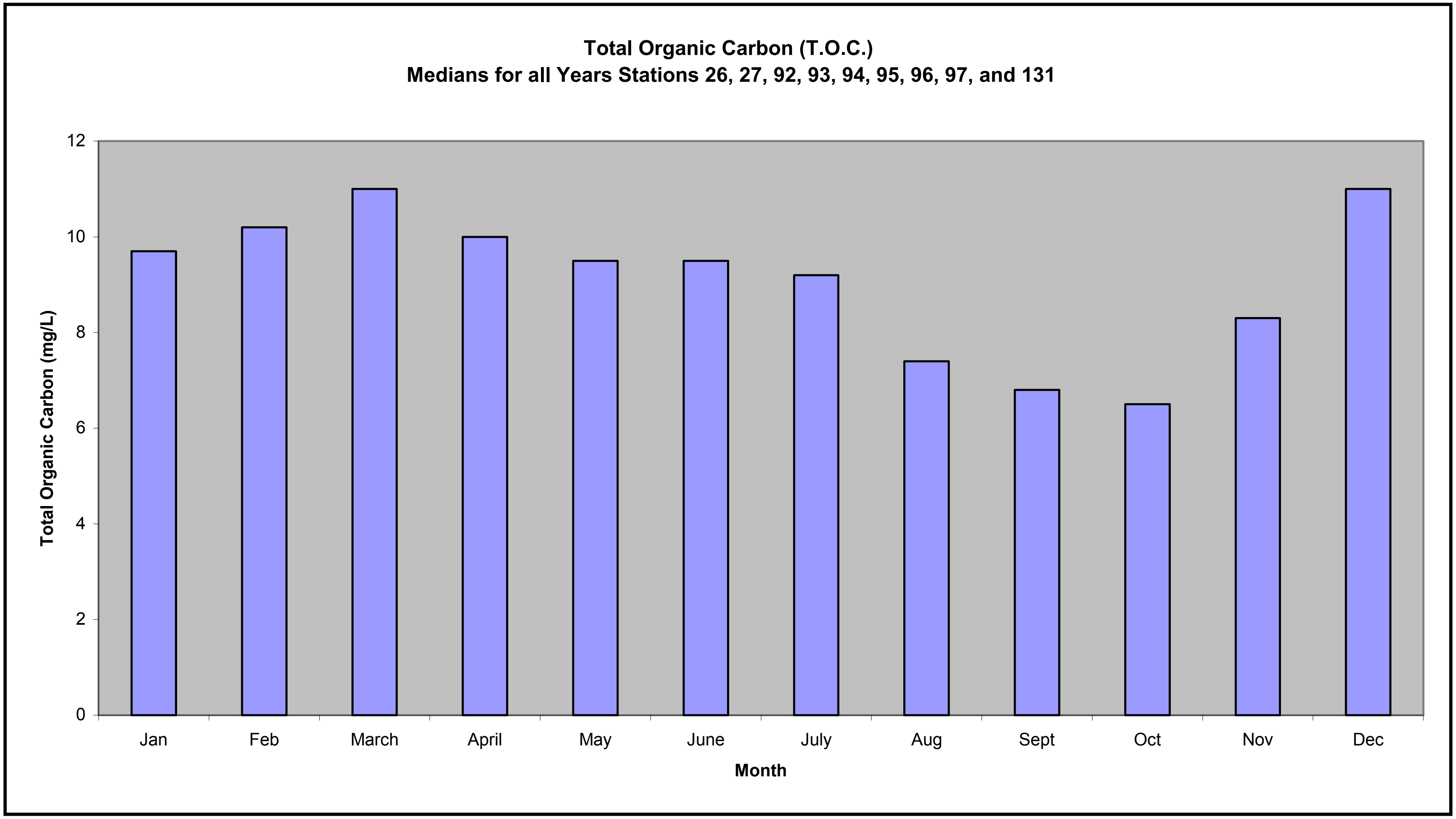

Turbidity
Medians for all Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
Turbidity (NTU)
35
30
25
20
15
10
5
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

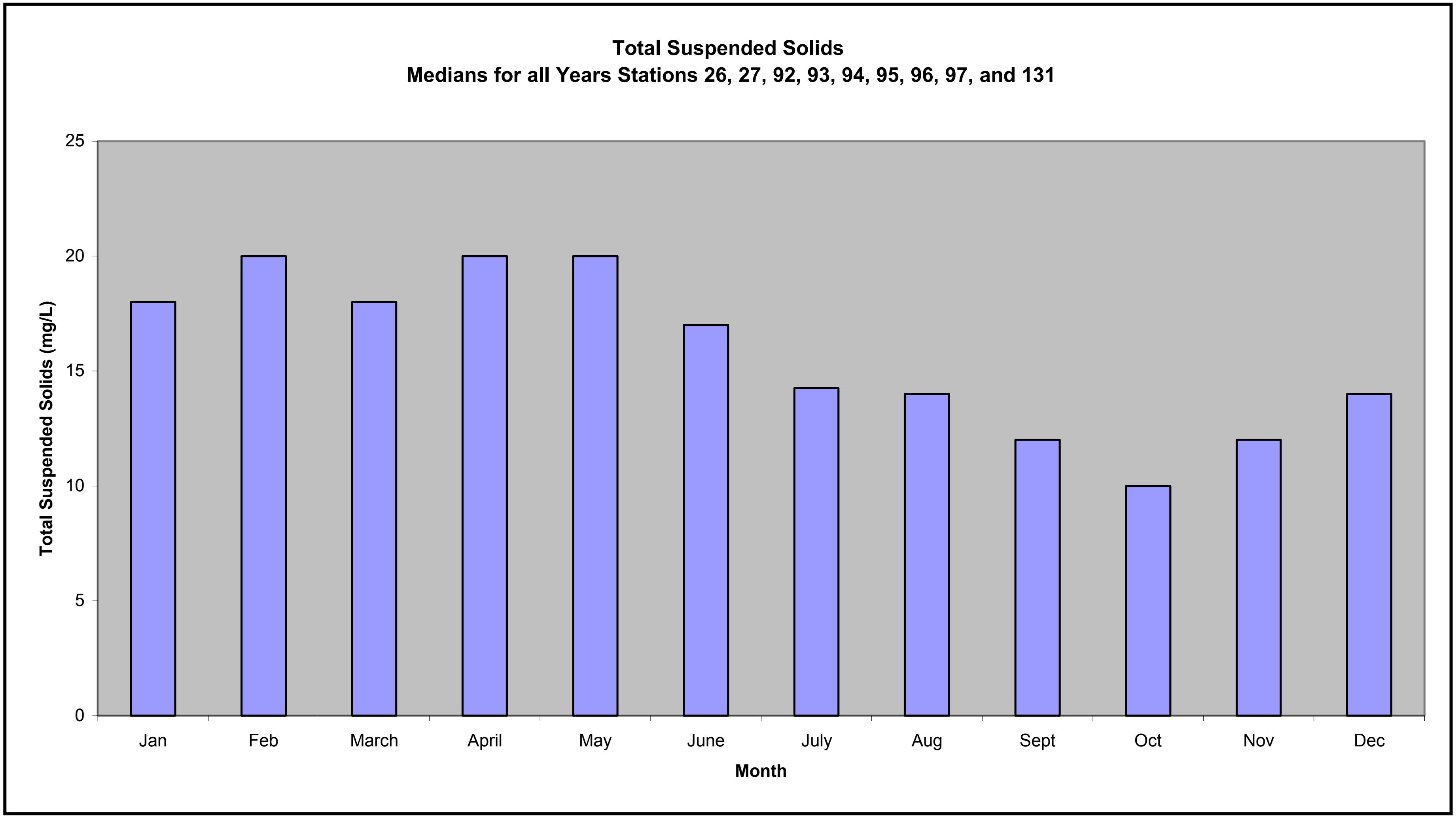

Total Kjeldahl Nitrogen (T.K.N)
Medians for all Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
T.K.N. (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

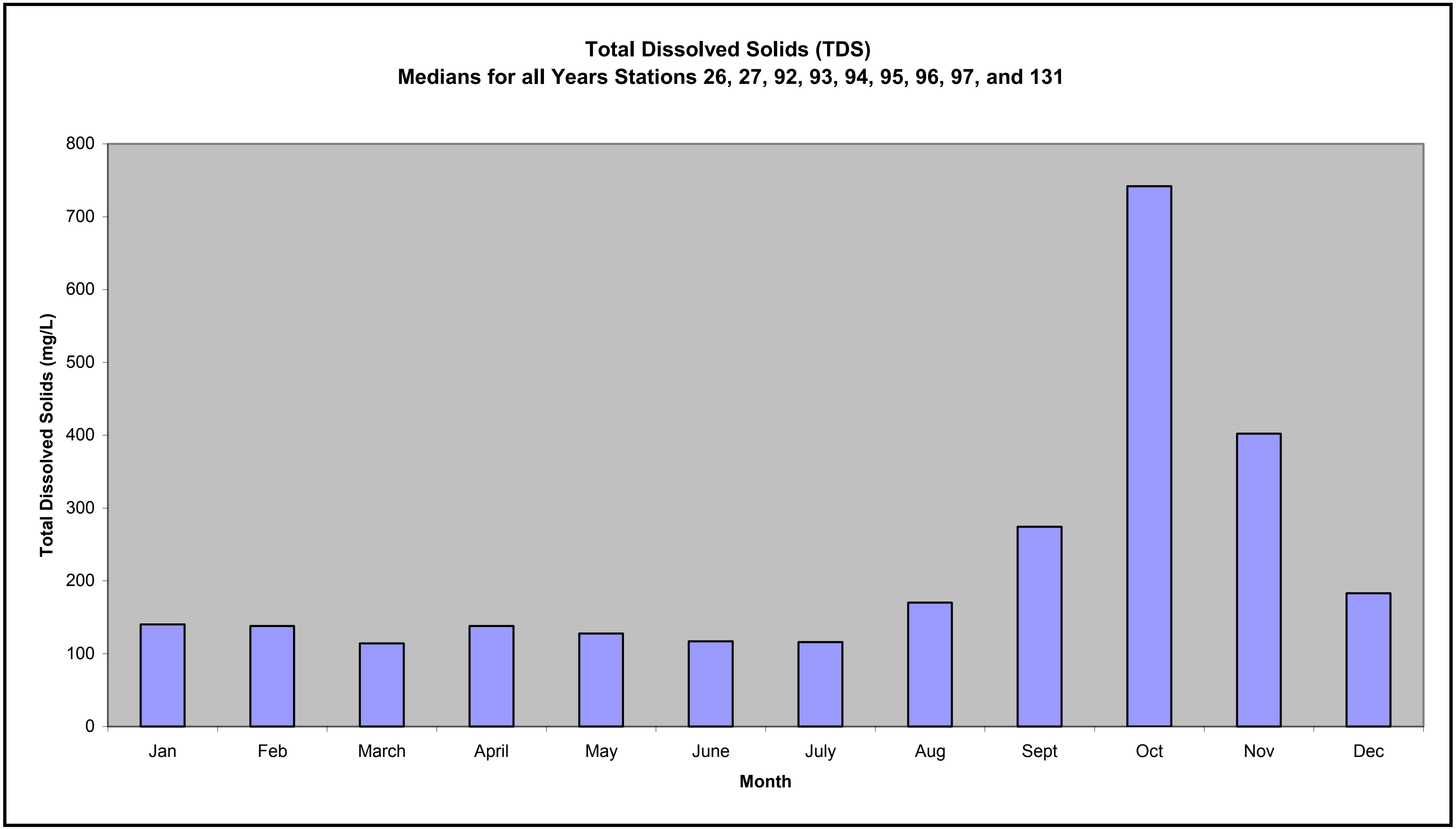

Total Phosphorus
Medians for all years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
Total Phosphorus (mg/L)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


Secchi Disk
Medians for all Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
Inches Secchi Disk was Visible
25
20
15
10
5
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


N02 + NO3
Medians for all Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
NO2 NO3 (mg/L)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


Total Organic Carbon (T.O.C.)
Medians for all Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
Total Organic Carbon (mg/L)
0
2
4
6
8
10
12
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


Total Suspended Solids
Medians for all Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
Total Suspended Solids (mg/L)
0
5
10
15
20
25
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


Total Dissolved Solids (TDS)
Medians for all Years Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131
Total Dissolved Solids (mg/L)
0
100
200
300
400
500
600
700
800
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month